40th

BIENNIAL REPORT

OF THE

BUREAU OF

GEOLOGY AND MINES.

STATE OF MISSOURI.

1898.

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BIENNIAL REPORT.

To His Excellency, Lon V. Stephens, President, the other Honorable members of the Board of Managers and the people of Missouri:

GENTLEMEN—Without reflecting unkindly on any previous administration of this office, the State Geologist has good reasons for congratulating the Board of Managers and the people of Missouri. That it was a happy day for both, the Geological Survey and the people who pay for it, when Governor Stephens decided to name a Board of Managers of practical business men of sterling integrity, is already demonstrated by the good feeling now existing between this Department and the people.

That the Survey had grown unpopular with the unlearned masses is a fact which goes without saying. That it had failed to unfold or delineate the physical conditions which would have furnished even the learned with a rational clue to the vast undeveloped resources of Missouri, is also a fact that is becoming every day more painfully apparent. The reports are voluminous and yet they do not contain the kind of information the people are seeking. Inquiries are continually coming into this office about economic deposits of other minerals than those now being mined. The reports of former geologists do not supply any definite information or clue to them. This deplorable sequence may be referred to the fact that the Survey did not proceed on a logical plan or that the earlier reports on the more interesting subjects were issued prematurely.

Howbeit, the present Board of Managers sounded the right chord, when it declared that the purpose of this Survey is to delineate the geology of Missouri, on a comprehensive plan; making it so logical and plain that even the humblest citizen may be a beneficiary. With that end in view, a plan was evolved and adopted that will soon bring the whole subject within the grasp of the average reader.

THE PLAN.

The plan, evolved and adopted by the Board, is:

First—To eliminate all irrelevant schemes and concentrate the energies of the Survey on field work.

Second—To work out ten continuous cross-sections of the State from southeast to northwest, on parallel lines, about thirty miles apart.

Third—To delineate the Geological Record of Missouri and the distribution of its various members, in a

(1) Report on Physical Structure or Structural Geology.

Fourth—To individualize the ore-bearing country rocks and delineate the requisite structure in them for economic bodies, in each productive horizon of the older rocks and in the Coal Measures, in a

(2) Report on Economic Deposits and Local Development.

Fifth—To construct, with the data collected for the above named reports, a correct

(3) Geological Map of Missouri.

Now, analysing the plan and taking up each section, in its numerical order, the reader will doubtless expect a full definition of each.

DEFINITIONS.

First—On entering this office, the Geologist found that a considerable amount of money had been expended on Engineering Instruments, Photographic Apparatus, Laboratory Equipment, Engravings for Printing Topographic Maps and many other things pertaining more to a school of engineering or physical geography than to a geological survey. Seeing that the energies of the Survey had been thus largely expended on the ornamental, without having duly emphasized the economic features of the work, the present management determined at once to eliminate all such ornamental or irrelevant fancies and go directly after the fundamental facts, which make the only logical foundation for a Geological Survey.

The first labor was to prepare and then occupy new quarters in the Armory Building. In removing the property of the Survey from the Capitol Building, the Geologist was sorely reminded of the old saying: "a man never knows how rich he is, until he moves." It transpired that an incredible quantity of costly but irrelevant plunder had accumulated during the previous eight years. Such of it as could be utilized or stored in the new quarters was removed and the remainder dumped or turned over to the proper authorities.

The removal cost the Department about one thousand dollars and three months of the Geologist's time. It was, however, a good thing for the Survey; because it helped to suggest a definite and logical plan. Finding, in the meantime, that contracts had been made with an Engraving Company in Baltimore for several additional Topogrophic Plates and that the engraving would cost between two and three thousand dollars, it became apparent that about one-half the appropriation for the biennial period had been already consumed. That, of course, suggested rigid economy during the remainder of the biennial period.

It was then too late in the fall to commence systematic field work. There were many calls, from corporations and individuals throughout the mining districts and unexplored regions of the State, for local surveys or assistance in the line of mine engineering. Desiring to husband its resources as much as possible and at the same time acquire definite knowledge of the country rocks, the physical structure and character of all productive ore bodies and other economic deposits, the Geologist was generously provided with free transportation by all of the principal railroads and instructed by the Board to answer all such calls, when the beneficiary would agree to pay his expenses.

Instead of renewing the laboratory equipment and thus entail a heavy expense, the assay work of the Survey was given to Prof. F. A. Jones of Kansas City. Prof. Jones, a native of Missouri, a gentleman and a scholar, was the Government Assayer for the Argentine Smelter. It has, ever since, been the practice of this Department to examine prospective mines, when it did not interfere with regular field work, give advice in mine engineering and one or two free assays, with the view of promoting cautiously the development of our mineral resources. Many persons have been thus encouarged to follow up profitable leads or dissuaded from pursuing phantoms. In that particular function, the Survey has been eminently successful and has made many friends. Fully nine-tenths of the rock and ore-specimens sent in have been determined in the office. Analyses of the other one-tenth have cost the Department little or nothing as compared with the fixed expense of maintaining a laboratory and keeping a competent man always on hand to run it.

Without a sufficient fund to provide for the salary of an expert in the office, when the Geologist was out on field work, such mail as the lady Secretary could not satisfactorily answer was laid on the table until he returned. That accounts for unpleasant delays in a very few instances. Obviously, the Geologist could not be in the office and at the same time out on field work. The reader will, of course, understand that the Department is not complaining but merely offering a true explanation to those who may have had to wait sometimes for its replies. Moreover, it must be apparent to any reasonable person that the Geologist cannot afford to be very much hampered with engagements or correspondence while on field work. It requires about all of the energy of an ordinary man to contend with the weather and other incidental difficulties, and at the same time perform such effective field work as this plan implies.

Second—The ten continuous cross-sections, provided for in the plan, suggest that the State will have been quite generally explored and its physical structure quite thoroughly worked out before a finished report on that subject will be issued. Although the ten cross-sections will, in fact, be on definite diagonal lines, parallel with each other and at right angles with the axis of the Ozark Range, the field work required to work them out, true to nature, will necessarily have familiarized the survey with the geology of the whole State. Hence, too much emphasis cannot well be placed on that feature of the plan. During the first eight years the Survey had been going on, many whole counties had never been invaded by it. That, alone, was enough to create distrust in the economic value of a Geological Survey.

On the plan evolved by this management, the State Geologist, leading in the field work, will have explored personally every county in the State before any finished report is issued. The structural geology of each cross-section, traversing the State diagonally and at right angle with the axis of the Ozark Range, displayed in a vertical zone, will give the people a definite idea of not only the geology of their own county, but of its relation to the geology of the State. The time required and the cost of thus delineating the geology of the State, will not be more than a correct topographic map of one county. Such definite information as the people are seeking will be brought out, and all the people of the State will be the beneficiaries.

The fossils of each member of the geological record will be studied and noted along with its physical characters and distribution. To those who do not quite understand the meaning of geological record, this explanation is offered: resting on the crystalline Primordial shell of the Earth or its igneous lenses, in a persistent wrapper of sedimentary rocks containing legible organic forms or fossils, is the Historic shell or Geological Record. In the central zones of the greater downward folds or inverts, the geological record is immensely thick. In the central zones of the greater upward folds or arches, it is often surprisingly thin or absent. For example, we have in certain denuded areas in Southeastern Missouri, igneous lenses of the primordial protruding through the geological record. On the other hand, in Northwestern Missouri, our geological record is not less than 3,000 feet thick. There is no conceivable plan that will unfold these facts so effectually as the cross-sections.

The question will doubtless arise in the mind of the reader why the ten cross-sections are to be worked out on parallel lines from southeast to northwest? The Ozark Range, an ancient upward fold or unevenly developed arch, traversed the State from the beginning of Paleozoic time and predetermined its physical structure. Subsidence of the Illinois invert on the east and of the Missouri invert on the west, tended to emphasize the intervening arch more and more until the development of the Rocky Mountains relieved the lateral pressure. In that more developed and more denuded portion of the Ozark Range, south of the Missouri River, we find the igneous primordial rocks protruding through the geological record. That it was a very ancient terrane is shown by the fact that Trenton limestone, one of the most important members of our geological record, is nowhere found in Southwest Missouri. On the other hand, in Northeast Missouri, the Ozark Range is nothing more than a sinuous ridge or upward fold between the Missouri and Illinois coal fields. In Ralls county, between New London and Shiel, the Trenton limestone describes a complete arch—rising out on the east, from under Hudson River Shales and other overlying rocks and descending again at Cedar Creek, to the westward, under the same kind of rocks.

Conceiving now, that the axis of the Ozark Range lies in a sinuous line across the State, from southwest to northeast, it is easy to understand why the eastern boundary of the Missouri coal field should be even a more sinuous or crooked line. It must be borne in mind that the development of the Missouri and Illinois coal fields was coincident with the later development of the Ozark Range. The subsidence of two opposing inverts means the logical development of an intervening arch. Coal forests could not have flourished on as many different horizons, as there are letters in our alphabet and have been buried, one after another, as they are, elswhere than on the floor of a subsiding invert. The Ozark Range, is therefore, to be regarded as an unevenly developed arch between two great inverts.

Moreover, the physical structure of the Missouri coal field, as already indicated, is intimately related to the Ozark Range. One is the complement of the other. Although the Ozark Range is less developed on the north side of the Missouri River than on the south, it, nevertheless, makes a complete division of the Missouri and Illinois coal fields. Furthermore, a cross-section of the Missouri coal field from southeast to northwest will show a very different structure from what has been heretofore taught. About parallel with the axis of the Ozark Range there are evidently three important dislocations in the bed-rocks of the coal measures, which divide the coal field into four distinct terraces or zones, in each of which the beds lie comparatively level. The greatest depth of the coal measures in the first or Chariton zone is not exceeding 300 feet from surface to bed-rock. In the second or Grand River zone, not exceeding 800 feet. In the third or Platte River zone, not exceeding 1,300 feet. In the fourth or Forest City zone, not exceeding 1,800 feet.

Again, conceiving the Ozark Range to be a dividing arch between two great inverts, let us imagine an open cut 2,000 feet deep on a straight line from St. Louis to Forest City. What a surprising picture would the rocks in either wall of that cut make! You would have a little patch of the Illinois coal measures at the top of the St. Louis end, Missouri coal measures down very nearly to the bottom of the Forest City end, with the crystalline base and nearly every member of our geological record displayed between. Imagine another such cut from the point three miles north of Grand Tower to Westport. You would then have the basal sandstone and Kaskaskia limestone of the Big Muddy coal field at the east end, 800 feet of Missouri coal measures at the west end and crystalline or igneous rocks rising nearly or quite to the top of your sketch in several places between. Again, from Cape Girardeau to Westline, in Cass county, the igneous rocks of Madison and Iron counties would divide the geological record completely.

Take either one of the lines mentioned, for a base, draw nine more lines parallel with it and about thirty miles apart and you have practically the line of each cross-section. Why are they to be worked out on diagonal lines from southeast to northwest? Simply because they cut the axis of the Ozark Range and the different zones of the coal field at right angles; thus unfolding the structural geology of the State completely. In working out one of these cross-sections, the Survey is tacking a zone right and left and taking in everything of special interest on either hand. The money appropriated for the Survey is distributed among the people and the people of the whole State are the beneficiaries.

The only additional scheme for making the cross-sections more nearly exhaustive, that the Geologist can suggest, would be to put down a few holes, with the core-drill, through the geological record and into the crystalline rocks, in different places. While there is no question in his mind but that it would be a splendid investment, there is, however, a question about whether the holes could be so distributed as to give entire satisfaction to the people of the State. Furthermore, it would imply an additional appropriation of ten or twenty thousand dollars, according to the number of holes.

The Geologist thinks economic deposits might be thus unfolded that would a thousand times more than compensate the State for the experiment. He knows that the information, thus obtained, would be equal in value to the cost.

The crystalline rocks have been penetrated in several places in Missouri, outside of the recognized porphyritic and granite region, but the records have, in most instances, been lost or made so indefinite by the use of the churn-drill, that they are now worth very little more than ordinary tradition. Drill-cores of mica-schist have been taken from below the geological record in Southwestern Missouri and yet, there is no account of Trenton limestone having been touched. The writer has seen cart-loads of drill-cores dumped in the dooryards of farmers, for the purpose of ornamentation. Had they been filed in a case and thus preserved, in their exact order of occurrence, they would have furnished information of priceless value to future generations.

Moreover, the fact, that the Trenton limestone describes a complete arch in Ralls county and dips away to the westward under its normal covering, suggests that it may spread out under the greater part of North Missouri. The well-known fact that productive oil lenses are found on the inverts of the Trenton, while all of the gas of economic value is found in the upward folds or arches of the Trenton, where they are covered by a considerable thickness of impervious beds, makes the Trenton arch in Ralls county a physical condition of the greatest importance. It may lead to the development of a new oil and gas field, in North Missouri, equal to any that has yet been discovered in the Mississippi Basin.

If Trenton limestone does exist under Northwest Missouri, it is manifestly at such a depth and is so covered by the impervious shales and clays of the Coal Measures, that whatever gas it may have generated is necessarily still in stock. Between the Platte and the Nodaway, lies an upward fold or arch in the superficial beds, which fact suggests a greater fold in the rocks at a depth of two or three thousand feet. Again near Avalon in Livingston county, an upward fold, already traversed and noted by the writer in October as the complement of the Bonanza Basin in Caldwell county, has since been determined a deep seated arch, by recent borings for water. That a few holes judiciously distributed and put down with the core-drill under the supervision of the Board of Managers of this Survey, would unfold information of the highest value, there cannot be any doubt. What dissatisfaction might arise out of the distribution of the holes is an unknown quantity. What arrangement might be made with the immediate beneficiaries of any important discovery is another matter to be considered.

Without the drill-holes, the cross-sections will be worked out and the structure displayed with reference to the surface exposures and characteristic persistency of each important member of the geological record. The upper portion of each vertical zone, thus delineated, can be made absolutely correct. The lower portion must, however, be necessarily ideal. It must be apparent to any thinking person that the definite information to be obtained from a dozen or more holes, judiciously distributed and put down with a core-drill, would more than compensate for the expense. So valuable an adjunct to the requisite field work would make the Report on Structural Geology practically exhaustive.

Third—The Delineation of the Geological Record means that the lithological and fossil characters of each important rock or horizon, from the crystalline primordial to the quaternary, shall be shown in its logical or natural order of occurrence. Obviously, the geological record has two phases: 1, its physical or lithological character; 2, its paleontological or fossil character. Each of these characters has its value, and these values do frequently alternate. We can, sometimes, more readily recognize a rock or horizon by its lithological character and geological relations than by its fossils. Especially so, when none of its fossils can be found. On the other hand, we sometimes find a rock or horizon so altered, by local conditions, from what we consider its normal appearance, that we have to determine its age or geological sequence by its fossils. In such places, fortunately, where the underlying or overlying rocks are not exposed, the individual with which we have to deal is generally richest in fossils.

The geological record is divided first into geological periods. Each geological period embraces a certain portion of a vertical section, great or small, according to the relative local development of that period, in which the lithological and fossil characters show a long duration of similar conditions on the earth. Each geological period is subdivided into vertical zones called ages or formations, in each of which the lithological and fossil characters show a pronounced genetic relationship. Each formation or age is subdivided into individual members and each member is still further subdivided into two or more horizons as, for example, the Upper, Middle and Lower Trenton limestone.

Assuming, always, where the beds lie in normal position, as they were deposited, that the lowest came first and are, therefore, the oldest, the delineation of the geological record begins logically at the bottom and proceeds upwards. This plan will, no doubt, be a little confusing for a while to those who have been numbering either the coal horizons or the magnesian limestones downwards. But it is logical, whether "scientific" or not; and the Board of Managers has instructed the Geologist to proceed on that plan. The delineation of the geological record will, therefore, begin with the bottom of the Cambrian and proceed upwards, through the different geological periods in their natural order of occurrence; and, wherever there is a numerical order to be observed in either formations or horizons the lowest or oldest will be first, the next oldest will be second and so on to the end.

CAMBRIAN SECTION OF OUR GEOLOGICAL RECORD.

Taking the first Infusorial or basal sandstone of Mine La Motte, for the First member of our geological record, we have, between it and the next Infusorial sandstone or base of the Silurian, four massive oolitic magnesian limestones in the Cambrian: 1st, "The White Lead," 2nd, "The Dead Rock," 3rd, "The Black Lead," 4th, "The Cap-rock." At the top and bottom of the Black Lead, in persistent lenses, are the Lingulella shales. Lingulellæ are also found in the ore-matrix or limestone. The reader should bear in mind that in these rocks there are no cherts and that the Lingulellæ are the only legible organic forms. To many, it will be interesting to know that our disseminated lead ores do not occur on any other horizon or in any other country rocks but these.

The lower members of the Cambrian group, except the basal sandstone, are rarely ever exposed to view. The cap-rock is, however, the surface rock in the valleys of the porphyritic region and in certain small areas in South-Central Missouri. The basal sandstone, resting on porphyry and granite, is the surface rock in the high ground about Mine La Motte. The impervious character of the upper portion of the basal sandstone, suggests that it has been made so, by the absorption of mineral solutions from above. In fact, the sand-rock floor of the White Lead, in Mine La Motte, is known as "The

Sulphides." From it, the rare minerals, nickel and cobalt, are obtained. The oolitic texture and other peculiarities of the white and black leads show that these rocks have undergone vast chemical and mechanical alterations. That they have been the pervious receptacles, resting on an impervious bed, in which the residuary lead ores from overlying rocks, now weathered off, have been concentrated by the water, from time to time, there is every reason to believe.

These rocks, as a rule, lie comparatively level in the valleys, while the porphyry and granite hills rise up in bold relief. Indeed, there are many interesting things to be said about these Cambrian limestones, the conditions of occurrence and probable genesis of the wonderful disseminated ore bodies they contain. But we are now taking merely a passing glance at our geological record, from bottom to top or from first to last. The white and black leads, as their names indicate, are the only ore-bearing rocks of the group. They vary much in thickness, in different localities, as well as in the percentage of ore they carry. Their normal thickness, however, is between five and twenty feet each. The "Dead Rock," between the white and black leads, as its name indicates, carries no ore of economic value. It varies in thickness, as far as explored, between ten and one hundred and fifty feet. The cap-rock, in its full developnent, reaches a total thickness of about two hundred and fifty feet. It ends, however, in alternate clay-shales or clay-wackes and thin layers of ferruginous limestone. In many places, where it is the surface rock, the shale-beds and thin layers of limestone have been removed and the massive portion only is in sight. So much for the Cambrian.

LOWER SILURIAN.

Now comes the Second Infusorial or basal sandstone of the Lower Silurian. It rests unconformably on the Cambrian cap-rock. Its unconformity is so pronounced as to be recognized in many places. In some places, the shale-beds and thin layers of the Cambrian cap-rock are in place, under the sandstone; in other places, the sandstone fills deep ravines in the much eroded upper surface of the massive cap-rock. This Second Infusorial or basal sandstone of the Lower Silurian is very persistent. It was evidently at one time very nearly if not quite continuous. In many places, its particles are concentrated into a massive homogeneous quartzite and it is frequently so stained with iron as to be easily mistaken for porphyry. That it makes a poor soil, is demonstrated by the fact that it is one of the principal horizons on which the pine forests of Southeastern Missouri grow.

Resting conformably on the Second Infusorial or basal sandstone of the Lower Silurian, comes the First Siluro-magnesian limestone. It is thus named, partly to preserve its individuality, partly for the want of a better name. The name, however, is not more unique than its lithological and fossil characters. This rock is distinguished by its gnarled, massive and open structure, its many great caverns, its big springs and its numerous fissure mines. It is further distinguished by the absence of the so-called "cotton-rock" which abounds in the later magnesian limestones. That it was, at one time, an exceedingly silicious limestone, is fully demonstrated by the vast quantities of chert and druzy quartz it has produced. In fact, many old fragments of the rock have been picked up that show the residuary siliceous matter concentrating into druzy quartz while the lime and magnesia are being dissolved out. In a long continued process of reconstruction, its fossils have been eliminated from the rock and are now found only in its cherts. Its fossils are, however, sufficiently abundant and related to Trenton species as to place it unequivocally in the Lower Silurian. The unconformity of its basal sandstone, to the cap-rock of the Cambrian, has been already sufficiently emphasized.

The first Siluro-magnesian limestone, varying in thickness between three and five hundred feet, is the surface rock over all of Washington county, north of Big river; and across Franklin county to the Gasconade, between Moselle and St. James. It is the surface rock over much of Crawford, Dent, Reynolds, Carter and Shannon counties. It is also the surface rock over large areas in Phelps, Pulaski, Maries and Camden counties. While not the surface rock in all of that vast area of sinks in Howell, Oregon and adjoining counties, it was the reconstruction of this rock that gave rise to the marvelous topography of that region. The Grand Gulf, near Koshkonong, the Meramec Big Spring, Fisher's Cave and the weird freaks of Ha Ha Tonka, are all due to the reconstruction of this rock. It is rent with many great open fissures which are now the tracks of subterranean streams. Many of the one-time open fissures have, however, been refilled with metallic ores, gangue-minerals and other economic products. The open fissures served as receptacles or lodging places for the residuary minerals of overlying country rocks that are now weathered off and gone.

The sooner the people of Missouri can be made to understand that it was only in the ancient canons and open fissures of the Silurian country rocks, productive ore bodies were planted, the better for them. The mineral deposits that have been concentrated in the canons and fissures of this First Siluro-magnesian limestone are varied and surprising. Many rich mines have been worked and many more lie hidden under the cherts, clays and other relics of the once overlying rocks that are now gone. It does seem that any man who has a right conception of the genesis of these ore bodies would know how to distinguish between the gangue-minerals or infilling of the fissures and the country rocks which form the walls. But the Geologist has, in many instances, found the prospector digging in the stratified country rocks. Indeed, the energy that is being wasted on barren ground, while there are plenty of rich ore bodies untouched, is enough to suggest a geological survey that is both comprehensive and practical.

A survey that will individualize each ore-bearing country rock in our geological record, show its distribution and delineate therein the particular kind of structure in which economic deposits may reasonably be expected, is what the people want first. That may not be scientific enough for some individuals, but the so-called scientific touches, such as topographic maps and flowery essays on surface features, may easily be added afterwards. There is enough, however, in the geology of Missouri that is grand and beautiful, if delineated logically, to interest the average man without borrowing from other states or drawing on the imagination.

In their conditions of occurrence or physical structure, the economic deposits in the fissures and canons of the First Siluro-magnesian country rock, are so radically unlike the disseminated ore bodies of the Cambrian, as to be easily distinguishable. In the white and black leads of the Cambrian, the ore-matrix is the country rock itself. In the Siluro-magnesian the country rock makes the walls of a fissure by contraction and separation on vertical planes of nearly coincident through-joints. The gangue-minerals or infilling of the fissures are so unlike the wall-rocks in every particular as to be readily distinguished from them. The gangue-minerals are chert, calcite, barite, iron pyrites, limonite and other soluble rock-minerals; along with ordinary clay. In short, they are entirely unlike the country rock which makes the walls.

The next member of the geological record is the Third Infusorial Sandstone. It is not usually so thick as either one of the other three rocks of like origin and character, but it is generally more stained with iron. Neither is it so nearly continuous as the Second, simply because it has perhaps been more eroded. It is also a quartzite in many places, as well as the horizon of pine forests.

On the Third Infusorial sandstone, rests the Second Siluro-magnesian limestone. It forms the bluffs of the Missouri River, for the most part on either side, between Providence and Augusta. It is also the surface rock over the south part of Jefferson county. It is quite conspicuous and much used about the Capital City. It might, therefore, be well named the Jefferson limestone. In fact, the writer has been thinking about calling the First the Washington, and the Second the Jefferson, limestone. However, First and Second Siluro-magnesian will do for the present.

The Second Siluro-magnesian limestone (the same that Swallow called the Second magnesian) abounds in both chert and "Cotton Rock." Some people will recognize "Cotton Rock" when they have learned that it is the material with which the Penitentiary walls and the Armory are built. The true limestone of this member is a rough looking rock with a pecky, worm-eaten, appearance. It is, however, a very durable rock and much used for curbs, foundations and retaining walls. There are many prettier rocks but very few better ones for these purposes. This rock makes most of the barrens or rock-glades in Ste. Genevieve, Camden, Laclede and Cole counties. It is the country rock of the Ste. Genevieve Copper Mine, the Wright, Webster, Hickory, Miller, Morgan, Moniteau and Cole county, lead and zinc mines. It has many old channels, canons and sinks, and, quite a good many open fissures in it, but not nearly so many fissures that have been refilled with ores and gangue-minerals, as the First Siluro-magnesian. Most of the Hematite and Limonite iron-ores of Missouri have doubtless been derived from the Second Siluro-magnesian.

The "Cotton Rock" which makes up the major part of this member is an even combination of Magnesia, lime and infusorial sand in very fine particles. It sloughs rapidly and shows no tendency towards crystallization. That may account for the fact that it has not developed so much cavernous structure as the underlying member. Some of the so-called "Flint Clays" of Southeastern Missouri are doubtless relics of this rock; while those of Warren county are evidently relics of the Chouteau. Howbeit, the geology of Missouri, shows, to an experienced eye, more substantial proofs of downheavals than of upheavals. The coal "pockets" or reconstructed coal beds of Morgan, Miller, Moniteau and Callaway counties, planted in the old channels or canons of this particular country rock we are now delineating, are evidently made up of materials derived from the degradation of the regular Coal Measures and reconsolidated without pressure. Stumpe's clay-pit at Washington, Franklin county, is another instance of downheaval. It is simply a mass of reconstructed coal measure fireclay, with abundance of Coal Measure fossils, lying around to prove it. Again, the Coal Measure relics, found in the ore-matrix of the Bass Mines, in Cole county, tell the same story.

We come now to the Fourth and Last Infusorial or St. Peter's Sandstone. Whether or not there is anything in a name, it is the purest sandstone of them all. Inasmuch as that it is already thus named the writer will cling to it. To every person who has passed over the Missouri Pacific or the Missouri, Kansas and Texas Railroad, to St. Louis on a day train, the White Sand Quarries at Pacific on the one, or at Augusta on the other, must be a familiar sight. That, is the far-famed St. Peter's Sandstone. It is exposed near Eolia and at Silex, in Lincoln county, in the valleys of the Tuque and Charette creeks in Warren county, between Augusta and Matson, in St. Charles county, on both sides of the dividing ridge between the Missouri and the Meramec, in St. Louis county, again at Crystal City, on the Mississippi River.

But a more surprising exposure of this rock than any one of those mentioned above is at Spalding Spring, in Ralls county, where an inverted Trenton zone, about one-fourth of a mile wide and five miles long, has lifted the St. Peter's sandstone bodily out of its normal position, and it now lies, on top of the inverted Trenton, a pure quartzite. And yet, there must have been more downheaval than upheaval in that case, because the slice of Trenton limestone that is turned over is not less than three hundred feet thick; while the quartzite from St. Peter's Sandstone is not exceeding sixty or eighty feet thick.

Some of the most interesting geology in Missouri is to be found in the vicinity of Spalding Spring, and it is a most delightful resting place. Right across a narrow valley from the inverted Trenton zone the Trenton limestone, in all its grandeur, stands out in bold and picturesque bluffs and in its normal position. Every student of geology in Missouri ought by all means to visit Spalding Spring, in Ralls county, and Ha Ha

Tonka, in Camden county. They are both sublime places and have good accommodations at very moderate rates.

That the fourth and last Infusorial or St. Peter's Sandstone supplies the silica for all the glass industries in and around St. Louis must be a familiar fact to very many people. It is also used extensively by the clay-workers for moulding and parting-sand. Indeed, its economic value is inestimable.

Now, on the top of the St. Peter's sandstone, comes the Third and last Siluro-magnesian limestone. It, unlike the other two members of the same character under it, is a very shy rock; being, so far as the writer is now advised, nowhere exposed except in Warren, St. Charles, St. Louis, Franklin and Jefferson counties. It lies immediately over the St. Peter's sandstone in all the exposures mentioned, in those counties, but does not occur in Lincoln and Ralls counties where the Trenton rests immediately on the white sand. This last magnesian limestone is made up largely of a mottled cotton rock. In other words, the limestone is relatively thin, as compared with the cotton rock. It may be interesting to some people to know that a certain horizon or horizontal layer of this cotton rock, some ten or fifteen feet thick, has been determined a gold-bearing rock.

Under a thick section of the mottled cotton rock, peculiar to this member, lies a buff-colored or intensely yellow rock. The yellow color is, of course, referred to the per-oxide of iron or yellow ochre it contains. That this rock carries considerable gold, there is no longer any doubt. But whether the gold is in sufficient quantity to give the rock an economic value, has not yet been fully determined. However, the mere fact that a massive layer, in one of the members of the Siluro-magnesian group, does carry gold in appreciable quantity, helps to establish the genesis of not only our magnesian rocks, but also of the ore bodies they contain.

It occurred to the writer, some years ago, after having studied the Laurentian limestones of Lower Canada and the Magnesian limestone in North Carolina, where the first development of the Appalachian arch must have been, that those unique and heterogeneous products might be referred to the conditions which doubtless obtain on the floor of a sargasso sea. Having since studied the function of a sargasso sea, together with the unique characters of these Magnesian limestones in Missouri, there is, no longer any doubt, in his mind, but that the whole of our Magnesian Lens, Infusorial sandstones and Magnesian limestones, alike, was a heterogeneous mass of organic products, deposited on the floor of a sargasso sea; in Cambrian and Lower Silurian times. The various filtering processes, which must be in operation in all sargasso seas, in conjunction with the fact that they are invariably located on upward folds or shallow spots in the ocean, lead logically to such prodigious results.

Indeed, next after the volcanic cones, which must have been in all ages the outlets of renewal energy for the Earth's water and atmosphere, the first land surface on the face of this globe must have been the floors of sargasso seas. The Laurentian limestones of Lower Canada refer to the floor of a Primordial sargasso sea, which was the first emerged portion of this continent. Our Magnesian Lens refers with equal certainty to the floor of a sargasso sea, on the axis of the Ozark Range; from Primordial time to the beginning of the Trenton age. In addition to the obvious fact that sargasso seas are the logical filtering areas of the ocean, the myriads of organisms which inhabit them, subsisting, as they do, on elements taken directly from the water, could not well do otherwise than produce just such marvelous results.

Knowing furthermore as we do that the major part of the iron-ores of the world have been concentrated from a diffused state, by the action of organic acids, precipitating the iron on the floors of shallow lakes and ponds, and the dissolving out of the argillaceous matter afterwards, the gold-bearing section of our last Siluro-magnesian member is only a logical sequence. This is, indeed, a fascinating topic, but its full discussion would be too elaborate for this report. Its logical place is in the Report on Economic Products and Local Development.

Now comes the Trenton limestone and the Hudson River

Shales on top of it and that ends the Lower Silurian of our geological record of Missouri. While the Trenton limestone is, perhaps, the most interesting member of our Lower Silurian section, the Hudson River Shales are, on the contrary, the most monotonous and least interesting. That the Trenton represents a long period of clear seas and favorable conditions, for the development of marine life, is abundantly shown by its great volume and variety of legible organic forms. In fact, the Trenton limestone is nothing more nor less than a vast sheet of organic forms and matter. It must not, however, be forgotten that some of its characteristic species have their antecedents preserved in the cherts of each of the Siluro-magnesian limestones; while others have their descedants in the fossils of the Hudson River Shales. In fact, the generic relations of the fossil life in each of the three Siluro-magnesians, the Trenton and the Hudson River Shales are sufficiently pronounced to place all of these rocks together in the Lower Silurian of Missouri.

About the distribution of the Trenton limestone, in the western part of the State, that is obviously as yet a matter of conjecture. The fact that it does occur at Spalding Spring in its normal thickness and descends to the westward at Cedar Creek under its normal covering, the Hudson River Shales, there is no apparent reason why it should not reach continuously to the Missouri River at St. Joseph, and all over Northwest Missouri. If so, on its downward folds or inverts, we may expect to find oil; in its upward folds or arches, we may expect to find gas in great abundance. As, already stated, it has not yet been recognized in Southwestern Missouri, where later and younger rocks rest on the older, Second Siluro-magnesian. On the eastern edge of the State, between Spalding Spring, in Ralls county, and Gray's Point, in Scott county, its exposures are too numerous to mention.

Trenton limestone is the surface rock over a large portion of Lincoln and Pike; it makes the most picturesque bluffs on the Missouri between Matson and St. Charles and on the Meramec between Pacific and Valley Park. It is used extensively in the manufacture of lime in St. Louis county and more extensively at Cape Girardeau; where the Lower Trenton reaches its greatest development at Cape Rock, above, and towards the Rock Levee below. There is a splendid exposure of Middle or massive Trenton on the Burlington track, near Elsberry, suitable for making lime.

The Hudson River Shales, like all other shale-beds, represent an epoch or transition period of muddy seas. Beyond that, there is little to be said about the closing member of our Lower Silurian. It consists of alternate layers of bluish green clay-shale and thin white lenses of calcareous mud-rock or argillaceous limestone, as you prefer to call it. In the bluffs just south of Louisiana, in Pike county, these shales reach a maximum thickness of about 100 feet. But, like all other shale-beds, they vary incomparably more in thickness than any other member of the Lower Silurian. Obviously, the sediment precipitated on the floors of muddy seas would fall thickest on the lowest places or be afterwards carried there. Hence, it is a safe conclusion that shale-beds and ordinary argillaceous sand-rocks are merely fillers for leveling up the inverts in the other rocks with their arches. This, as will be shown later on, is a fact of great value in locating economic deposits in the Coal Measures. So much for our Lower Silurian.

UPPER SILURIAN.

And now for our Upper Silurian. That the Hudson River shales do represent a transition epoch of muddy seas, is further demonstrated by the argillaceous character of the Clinton limestone, the first member of our Upper Silurian. In its lithological character it is closely allied to the argillaceous limestone of the Hudson River shales. Its fossil character is, however, quite different. It contains very many new species of small Brachiopods, by which it is readily distinguished from the preceding group. It also contains a few small corals which indicate a slight clearing up of the seas.

The Strathigraphic value of Clinton limestone is the only value it represents. The fact that it exists and that its fossil character places it in our Upper Silurian section, which is relatively small, are about the only things which entitle it to mention here. In the extent of its development it does not cut much of a figure in Missouri geology, being limited, so far as we are now advised, to a small area around the Buffalo Knobs, in the southern part of Pike county.

Next after the Clinton comes the Niagara limestone, the most important member of our Upper Silurian. The oolitic Niagara, resting on Hudson River shales, in the north bluff at Louisiana, Mo., is the next most conspicuous rock to the Lithographic or Louisiana limestone above it. Its oolitic feature does not, however, seem to have added very much to its economic value, for the Burlington limestone supplies all of the building stone that is used in that flourishing and delightful old river town. The most that can be said about the Niagara in Northeast Missouri is, that it is a massive argillaceous limestone, easily worked but of doubtful durability. It is quarried and used somewhat at Elsberry but more extensively at Bowling Green. It is also an important factor in the construction of the Buffalo Knobs. In Southeastern Missouri, notably Perry and Cape Girardeau counties, it is a decidedly more crystalline rock, approaching closely in texture to a commercial marble.

The Niagara limestone is remarkable mainly on account of its argillaceous character and abundance of corals; together with the fact that it is the equivalent of the famous Joliet limestone. Its Favosites, especially, are varied and abundant. Its chain corals are exceedingly interesting. How an argillaceous limestone could contain so many corals is a geological puzzle. While its lithological character points unerringly to muddy water, its fossil character points, on the contrary, to clear water and comparatively shallow seas. Howbeit, all of our Upper Silurian and most of our Devonian rocks have decidedly argillaceous characters.

Following, next after the Niagara limestone, comes the closing member of the Upper Silurian, the Delthyrus shales of the Lower Helderberg. Good exposures of these rocks occur at Red Rock Landing and at Lithium, in Perry county. In fact, nearly all of our geological record is exposed in Perry county, from the basal sandstone of the Coal Measures down. The Survey has not yet recognized Clinton limestone there, nor have all the members of the Subcarboniferous been located, but at Landing Seventy-Six and at a point on the bluff, between Lithium and St. Mary's, are two of the best exposures of Kaskaskia limestone in the State. The Ste. Genevieve sandstone, lying between the St. Louis and Kaskaskia limestones in that locality is, so far as known, a local deposit. Indeed, the geology of Perry county, when correctly delineated, will unfold some of the most surprising physical structure in Missouri. Returning to the text, the lithological character of the Delthyrus shales does not indicate any clearer water, or even as clear as the Niagara limestone, in that locality.

In the Clinton limestone, the Niagara limestone and the Delthyrus shales, you have all of the members of the Upper Silurian that have been recognized in Missouri. From an economic view, they have very little value. Neither is their extent, so far as indicated by their exposures, very considerable. In two particulars, they resemble very much the Chouteau beds at the base of the Subcarboniferous; the rocks are intensely argillaceous and the fossils are generally silicified. At Red Rock Landing, the writer found one immense Crinoid stem. At Lithium, he found fragments of two or three dozen Trilobites. That interesting Crustacean seems to have found his El Dorado in the muddy seas of the era.

DEVONIAN.

Proceeding, now, from the Upper Silurian to the Devonian, the first member of that section of our geological record, is the Hamilton group of shales and argillaceous limestones. These rocks have reached their greatest development in Callaway and Pike counties. They are rich in Brachiopods, but not especially interesting for any other reason.

The next member of our Devonian section is the Corniferous limestone, the only absolutely clear water deposit, between the Trenton and Burlington limestones. The best exposures of this rock, known to the Survey, are at Shiel or Sidney, in Ralls county; at Hibernia, in Callaway county; on Muddy Creek, in Pettis county; on Charette Creek, in Warren county, and at Grand Tower, in Perry county. In fact, that picturesque mass of rock, in the Mississippi River, known as the Grand Tower, is Corniferous limestone. Its corals are amazingly large and surpassingly beautiful. There is no coral in any other rock to equal its Acervularia davidsoni and Favosites hamiltonensis, in either magnitude or exquisite structure. Some splendid silicified specimens of these corals were collected about Wittenberg, others that are still normal limestone about Sidney or Shiel, in Ralls county.

After the Corniferous era, there was evidently a relapse to muddy seas; for the next two members of our Devonian section are the Lithographic or Louisiana limestone, and following it the Hannibal shales. These rocks, and their equivalents, form thick beds in the river bluffs from Louisiana to Hannibal, in the banks of the Osage river at Osceola, and in the cuts of the Kansas City, Springfield and Memphis Railroad, at Cedar Gap. Their fossils, like those of the Upper Silurian and the Chouteau, are usually silicified or pyritized. The Hannibal shales form the closing member of our Devonian. They represent another transition epoch of intensely muddy seas.

SUBCARBONIFEROUS.

The first member of our Subcarboniferous section is called the Chouteau Beds. As if Nature had meant to build an impervious floor, for the net-work of eroded fissures and one-time subterranean channels, in which the rich ore bodies of Southwest Missouri are planted, this vast aggregation of argillaceous matter forms the base of our Subcarboniferous country rocks. The Burlington, the Keokuk, the St. Louis and the Kaskaskia, are all intensely crystalline limestones, while the Chouteau beds are, with few exceptions, intensely argillaceous. Of the Subcarboniferous country rocks, just named in their natural order of occurrence, the Burlington and the Keokuk limestones are the chief, in Southwest Missouri.

But, before proceeding with the delineation and distribution of each member of our Subcarboniferous country rocks, the attention of the reader is called to the intimate relations between the Burlington and Keokuk beds. If they are really two distinct members of our geological record, the writer has not yet had the pleasure of seeing it satisfactorily demonstrated. In other words, he has not yet found, in Missouri or elsewhere, an exposure of the contact, between these two members, above and below which each has preserved its individualities. Neither has he found, among those who ought to know, a single individual whose convictions are quite clearly defined on that question. Inasmuch as that it is a fundamental feature of the plan of this Survey to eliminate, as speedily as possible, all such perplexing questions, so as to proceed tersely and with precision in the delineation of more important things, the Geologist is open to conviction and would be pleased to hear from any gentleman, who may be better informed, on that point.

Returning to the Chouteau, which is now generally recognized as the first and basal member of our Subcarboniferous section, it is, except in Pettis, Cooper, Saline and Callaway counties, so far as we know, very generally a massive argillaceous limestone, alternating with ferruginous clay-shales. Its "Vermicular" cap-rock, is clearly a reconstructed mud-rock. The Chouteau is a very persistent and widely distributed member of our geological record. It is easily recognized by its Vermicular sand-rock and shales, its Taonurus caudigalli, its silicified Michelinia expansa, its abundance of Conophyllum and exquisite little Cleistopora placenta; all of which are intensely characteristic. With few exceptions, Chouteau occurs in every locality in the State, wherein the base of the Subcarboniferous is accessible. It has been suggested by several persons, especially at Osceola, that this rock has a high economic value for the manufacture of native cement. That, however, has not yet been fully demonstrated. The Geologist fears that its argillaceous matter is relatively too great for its lime.

That the immense beds of massive white clay, near Warrenton in Warren county, are altered Chouteau beds, was suggested to the writer by their proximity and the close analogy of their structure. But they have not yet been sufficiently studied to determine their exact origin. One thing certain, all of our clays of economic value, except our Coal Measure fire-clays, may be safely regarded as the relics of disintegrated, altered or weathered-out rocks. That the so-called "Flint" clays of Southeastern Missouri are the products of decomposed "Cotton rock," is a far more probable genesis for them than their current name suggests. It would not require a very great effort of nature to dissolve out the more soluble minerals of an argillaceous limestone and leave a residue of plastic clay.

Burlington limestone, the second member of our Subcarboniferous section, is an intensely crystalline rock. In addition to the fact that it is one of the principle country rocks of our lead and zinc deposits in Southwestern Missouri, it is a successful competitor of the Trenton, in the manufacture of lime. In fact, there is really more lime made in Missouri from the Burlington than from the Trenton. Which makes the best lime, is a question that is difficult to answer; but they both make excellent lime and that is sufficient. The massive, crystalline Trenton, quarried at Cape Girardeau, for lime-making, seems to have every desirable quality. On the other hand, the Burlington limestone, quarried at Hannibal, Peirce City, Ash Grove and Springfield, seems also to have every desirable quality.

Next to the Burlington, if not its counterpart or equivalent, is the Keokuk or Carthage limestone. It seems a little strange that both these names should have been imported, when we have all those rocks ten-fold better developed and more persistent than they are in Iowa. Howbeit, we have, in the Burlington and Keokuk or Carthage limestones the principal country rocks of our marvelous lead and zinc deposits in Southwestern Missouri, and that is the main thing we are now after. It may not have occurred to the average reader that all sedimentary rocks, even the most crystalline, were one time mud-beds or uncrystalline masses. Indeed, the most crystalline limestones, now that we are discussing limestones, were one time uncrystalline masses and they must have remained so during countless ages.

In readjusting itself to its solid incandescent center, which is growing essentially smaller by sloughing on its outside and evolving renewal energy for Earth's water and atmosphere, this flexible shield of solid masses, on which we walk, is submitted to intense lateral compression. For example, like the peeling of an orange or an apple when the juice is evaporated, this solid shield of moveable masses is thrown logically into upward and downward folds by lateral compression. For convenience, we call the downward folds synclines or inverts and the upward folds anticlines or arches. The two equivalents, inverts and arches, may not suit the more scientific readers, but they are more in line with the purpose of this Survey and they express the thought quite as completely as synclines and anticlines. Every practical man knows the meaning of arch and invert and the radical difference between them. If not, let him draw a horizontal line across the end of any cylinder, at the middle point, and he has both ideas demonstrated.

The greater inverts, in Earth's flexible shield, are now the sea-floor. The greater arches are now the continents. There are, however, inverts and arches in the sea-floor. There are also midland inverts and arches in the continental masses. During the development of this continent, in Paleozoic time, the one great midland invert, now called the Mississippi Basin, was divided by the Cincinnati Ridge and the Ozark Range into three distinct inverts: the Appalachian, the Illinois and the Missouri. Paleozoic coal forests grew on the floors of those inverts, at the same time and under similar conditions. The coal forests grew, however, most luxuriantly and the accumulations of coal forest debris were greatest where the conditions were most favorable. That the coal forests did grow and were buried, one after another, on as many different consecutive horizons as there are letters in our alphabet, we have as many coal horizons in our geological record to show for it. How were the coal forests and their debris preserved from decay and converted into coal beds? They were preserved from decay, by the water in which they grew and were buried under sediment, during a subsequent period of subsidence. Whence came the sediment? Largely from the central zones of the Cincinnati Ridge and the Ozark Range.

But, this is a more elaborate illustration than was at first intended. However, as the earth grows older in her continuous effort to perform her function, which is clearly to evolve and develop organic life; her incandescent solid center, which means her pristine energy, is growing slowly but logically smaller. The whole of this flexible shield of ordinary solids, on which we walk, was one time enclosed in that watery envelope, which we now call the ocean. The only land was the volcanic peaks with their conduits, which were always essential to Earth's function. The ocean had its currents then as now, but the currents had a greater sweep then than they now have. The currents of the ocean swept round the upward folds or shallow spots, as they now do, and those shallow spots or filtering areas became the logical sites of sargasso seas. Primordial sargasso seas were the first emerged portions of the present continents. Paleozoic sargasso seas explain the genesis of our Magnesian Lens, known as the Ozark Range. Existing sargasso seas, wherein myriads of organisms are taking their food directly from the water, thus converting diffused matter into solid bodies and depositing them on the sea-floor, make it still plainer. In the meantime, the volume of neither water nor atmosphere is diminishing, because they are Earth's vehicles, in which are diffused the essential elements and food of organic life. As contraction went on, the greater inverts went down, the sea subsided and the land emerged; the same as the sand-bar in the falling river.

Really there is more downheavel in all this solid Earth than upheaval. Every phenomenon in nature is a logical sequence. Therefore, let us not be always trying to explain them with upheavals. When those uncrystalline limestones were relatively raised, by the subsidence of the sea, into land surface, the process of their reconstruction commenced in earnest and has never ceased for one minute. In fact, their reconstruction commenced from the time they were deposited; but when the salt water subsided and the fresh water invaded them, the process of reconstruction began which is now in operation.

That the alteration of an uncrystalline mass of organic products into an intensely crystalline limestone, means the separation of the latter on vertical planes of nearly coincident through-joints, into separate masses and the further contraction of each mass laterally towards its own center, is demonstrated by the familiar fact that all such limestones are notoriously cavernous. Indeed, nearly all of the great caverns of the world are in just such country rocks as these we are now discussing. The First Siluro-magnesian, the Trenton, the Burlington, the Keokuk and the St. Louis are the most crystalline limestones in our geological record, and they are all exceedingly cavernous. It is only natural that the open fissures, developed when these rocks contracted laterally into separate masses,should have become the tracks of subterranean streams. It has been shown that all the rocks in our geological record, between the Trenton and the Burlington, except the Corniferous, are decidedly argillaceous, and, therefore, naturally opposed to crystalization. It has been further shown, for the express purpose of this illustration, that the Chouteau base of our Subcarboniferous is emphatically an argillaceous rock, in Southwest Missouri; and, therefore, apparently designed by nature for an impervious floor to that vast net-work of subterranean channels, in the overlying country rocks that have been bodily refilled with soluble, reconstructed rock-minerals.

Mark these words: It is not in the isolated masses of country rocks the ore bodies are found, but in the reconstructed channels between them. Furthermore, the subdrainage system of that country, is the only rational clue to its rich ore bodies. The stratified beds which the miners call "Bars," are simply isolated masses of the country rocks. The spaces between, called "open ground," are the one-time open fissures, widened by erosion, into wide channels and refilled with rock-minerals, derived from various sources; and that calls for a more general illustration.

Keeping in view the Magnesian Lens or Ozark Range, as the rational source of the metallic ores and dolomitic influences, there must have been a time when most of Southwest Missouri was drained to the northwestward, in the direction of Wyoming. Otherwise, why should the Third or Upper Siluro-magnesian, the Trenton limestone, the Hudson River shales and nearly or quite all of the Upper Silurian rocks be missing in all that region? Furthermore, the story told by those numerous gravel beds, on the hill-tops, in Hickory and adjoining counties, is about conclusive. The gravel beds point backwards towards the summit of the Ozark Range; while the reversed drainage system flows eastward. The more recent development of the Rocky Mountains inclined the floor of an inland sea, towards Missouri and reversed our drainage system, to the utmost southern bounds of the Osage Basin. But the Spring River drainage system still flows westward.

The development of the Rocky Mountain Range means relatively the letting down of the Ozark Range in Missouri; so that our downheavals are still keeping pace with our upheavals. The development of the Rocky Mountains was, doubtless, a great relief to the lateral strain on the Ozark Range. Returning now, to the Spring River Invert or Joplin District, as it is sometimes called, it would be only logical to assume that its water-shed should have been one time much more inclined to the westward than it now is. If the development of the Rocky Mountains inclined the Laramie sea-floor towards the southeast and gave rise to the Missouri River, with all of its tributaries, why should not the water-shed of the Spring River Invert have at least been brought more nearly to a level? That all these deductions are true, the proofs are abundant and conclusive.

Now, the Spring River subdrainage system, flowing continuously in one general direction, from the Magnesian Lens into the Subcarboniferous country rocks, is the rational solution of both, the prodigious reconstruction of these rocks and the vast aggregations of gangue-minerals and metallic ores that have been carried into the widely eroded channels between them. That the ores are still gravitating, slowly but surely, with the subdrainage to the westward, is demonstrated by the familiar fact that the sulphides are more abundant to the westward; while the silicates and carbonates are more abundant to the eastward. In other words, the primary "Rosin Jack" is more abundant to the westward, while the secondary "Calamine," is more abundant to the eastward; and the galena cubes are generally bright and sharp to the westward, while dingy or rounded cubes prevail to the eastward, along with "Dry Bone."

Knowing, as we do, that when the water ceases to feed these ore bodies with new mineral or finding a lower track abandons them, leaving them high and dry, as it were, a new process begins—a process of reconstruction or degradation, as you choose to call it, the occurrence of either lead or zinc in the primary or secondary form, in apparent contradiction of this rule, is not a complete contradiction, after all. That a process of alteration should begin in these ore bodies as soon as the conditions are altered, by the letting down of the stream that has made them, is as logical as anything else in nature.

That the reconstruction of that vast aggregation of heterogeneous organic products and minerals, deposited on the floor of a sargasso sea, now represented by our Magnesian Lens, was the rational source of all our productive ore bodies, is demonstrated by the obvious fact, that neither economic ore deposits nor the requisite structure for them are found outside of that influence. Should it be suggested that rich ore bodies do occur in that area, wherein the whole drainage system has been reversed, the further fact, that they are invariably dingy or rounded cubes of lead and secondary or tertiary forms of zinc, shows that they have not been fed by new mineral since the drainage system was reversed, Ore deposits, like all other cosmic bodies, grow by accretion; while organic bodies grow by the addition of new cells. Organic bodies, we know, have to be continually fed. Ore bodies, when the stream that made them ceases to bring new minerals or is diverted by lower channels, are exposed to new conditions and reagents.

Having thus hurriedly individualized each ore-bearing member or country rock of our geological record and delineated therein the kind of structure wherein economic deposits may reasonably be expected, the Geologist will go one step further and say, without fear of successful contradiction, that all of our economic deposits, between the crystalline base and the coal measures, are water concentrations. That there are sublimation veins or plutonic deposits in our primordial eruptive rocks of Madison and adjoining counties, is highly probable; but it has not yet been demonstrated.

The old Einstein, Silver Mine, in the Granite rocks of Madison, was visited but the mine itself was not accessible. Several dykes of diabase were crossed in that county, as well as rumors of rich discoveries in the granite country rocks; but that was all. Why the people of Missouri should send to other states or countries for granite, seems strange, indeed, when there is, without limit and easy of access, as good granite here as elsewhere in the world.

Before leaving our crystalline base, now that we are in it, there are three places in that country of such surpassing beauty or geological importance as to deserve special mention: 1, the Elephant Rocks and granite quarries around Graniteville; 2, the granite rocks and dam on the St. Francois, at Silver Mine; 3, the Basin, round about Lithium and its peculiar water, which suggested its name. While the water is excellent and no doubt valuable, there are, perhaps, more geological puzzles in and around that Basin, than in any other equal area in Missouri. It will, therefore, furnish good exercise for not only the amateur but for the most advanced student. An occurrence on the farm of Mr. W. A. Lakeman, suggests, immensely rich ore deposits.

Returning, now to the Subcarboniferous, the Burlington and Keokuk beds or Carthage limestone are distinguished by their numerous Crinoid relics. The first, by its well-known Spirifer grimesi; the latter, by its well known Spirifer keokuk and Derbya keokuk; as well as its many beautiful quartz geodes and its exquisite Bryozoan horizon or cap-rock. Its Bryozoa suggest the most unique conditions that had ever existed on a sea-floor, to that time. The Bryozoan, archimedes, must have been the most elaborate and beautiful organic structure of that type that nature had yet produced. Indeed, it is a good analogue or illustration of the reproductive effort of our cosmic mother, Earth. Pentremites are also very abundant in the Carthage limestone, in many places. Everywhere, in Missouri, that the Subcarboniferous exists, these rocks are conspicuous or not far away. The Carthage limestone is well advertised by both its enterprising producers and its own intrinsic value, as a building stone. It occurs in good form at Boonville, Paris and near Troy.

Next, after the Carthage limestone comes the St. Louis limestone with its beautiful coral, Lithostrotion canadense. For the simple reason that it is the most available rock in and around St. Louis, it has been thus named and has yielded more good building material than any other member of our geological record. That this rock did, one time, spread out all over Missouri, is indicated by the fact that its characteristic fossil, Lithostrotion canadense, is found in its silicified form, in every county wherein the Subcarboniferous obtains. Such a ponderous and compact fossil, when solicified, is well nigh indestructible. Mr. Z. T. Snively of Wayland, Clark county, has presented the Survey with a magnificent specimen. Some ponderous specimens were also found in the bluffs of Saline creek, near St. Mary's.

Between the St. Louis and Kaskaskia limestones the Ste. Genevieve sandstone occurs. As already remarked, however, it seems to be only a local deposit, which may alternate with shale beds elsewhere. The top and last number of our Subcarboniferous section is the Kaskaskia limestone. Its Pentremites and Bryozoa suggest a recurrence of the same conditions that prevailed when the Carthage limestone was deposited. Between St. Mary's and Lithium, this rock is sufficiently massive, even grained and crystalline, to make it a valuable building stone. But it is not being used to any considerable extent, and outside of that particular locality it is not recognized elsewhere in Missouri except in Jasper and Newton counties. Its geological value lies mainly in its beautiful fossils and the fact that it is the top and last member of our Subcarboniferous.

THE COAL MEASURES.

The well known fact that our Paleozoic Coal Measures rest unconformably on all the members of the Subcarboniferous if not also, in some instances, on the Devonian and Silurian rocks, leaves no physical or lithological reason for using the misleading term, "Lower Carboniferous." It has been sufficiently shown that each member of our geological record has two characters: its physical or lithological character and its paleontological or fossil character. And that the geological age of a rock is frequently more easily determined by its lithological character and geological relations than by its fossils If, on the other hand, it is argued that the close relations between some of the Subcarboniferous and Coal Measure species are a sufficient reason for replacing an established name with one which carries in it a persistent falsehood, it can be truthfully said that equally close relations exist between some of the species of any other two consecutive periods, from the Lower Silurian upwards. "Lower Carboniferous" is misleading and is, therefore, eliminated, so far as the writer is concerned.

Our Coal Measure section reaches from the basal sandstone to the argillaceous limestone cap-rock of the Arkoe, Maitland and Quitman, coal horizon, in Nodaway county. For reasons which will hereafter become apparent, it is divided into three parts, the Lower, the Middle and the Upper Coal Measures.

THE LOWER COAL MEASURES.

The Lower Coal Measure rests on the basal sandstone and is capped by the Mahoning Sandstone. In its full development, it consists of eight coal horizons. That suggests the definition of the term, coal horizon. The Paleozoic soil or mud, on which the cumulative coal forest grew, or rested, is, logically, the first member of a coal horizon. The coal bed, itself, representing the cumulative coal forest, which must have grown and flourished under the beaming rays of our Imperial Motor, the Sun, is, logically, the second member. The first argilliceous sediment that fell on the sunken mass of forest debris and is now represented by the roof-shale or coal-slate, as you choose to call it, is, logically, the third member. Now, if the conditions of subsidence were such that sufficient sand or organic products, were precipitated on top of the first argillaceous sediment, to produce a persistent cap rock, it is, logically, the fourth member. A few coal horizons have no persistent cap-rock, but most of them have. In fact, all of the coal horizons of the Middle Coal Measure except the second have limestone cap-rocks, and all of the coal horizons in the Upper Coal Measure have limestone cap-rocks without any exception. And now, it is well to note that they are nearly all intensely argillaceous.

The Lower Coal Measure is easily distinguished from either the Middle or the Upper, by both, its lithological and fossil characters. It contains neither limestone rocks nor marine fossils. There are no limestone rocks between the basal sandstone and the Mahoning Sandstone; Cap-rock, of the Lower Coal Measure. In its full development there are, however, eight productive coal horizons in the Lower Coal Measure. In speaking of either coal beds or ore bodies the word, productive, means that the volume and structure are such that the deposit may be profitably worked. For the primary reason that coal forests grew in isolated bodies or spots and flourished most where the conditions were most favorable, the same as vegetation grows now, it rarely ever occurs that more than two or three productive horizons are found in one spot. But, inasmuch as that coal horizons are the very best marked geological horizons that we have, they are, for that reason, the most persistent. In fact; the members of a coal horizon are the only constant rocks in the Coal Measures.

If, in Paleozoic time, when this continent was in process of development, any single paroxysm of contraction had forced the floor of the Appalachian invert down and thus produced the subsidence of a certain coal horizon, in that invert, is there any conceivable reason why it should not have done the same thing in the Illinois and the Missouri inverts? That it did, is made conclusive by the fact that the Lower Coal Measure, in its full development, contains exactly eight coal horizons in each one of those three great inverts. The productive horizons of, the Alabama coal field, the southern portion of the Tennessee coal field, the Eastern Ohio coal field, the Big Muddy invert of Illinois, the Arkansas and Indian Territory coal field, are all in the Lower Coal Measure. In the Appalachian invert, a great conglomerate sheet occurs in the middle of the Lower Coal Measure. The four upper horizons, between the conglomerate sheet and the Mahoning Sandstone cap-rock, are the productive horizons in Ohio and Pennsylvania. The four lower horizons, between the basal sandstone and the conglomerate sheet, are the productive horizons in the Southern Tennessee and Alabama coal fields.

The great conglomerate sheet in the middle of the Lower Coal Measure, in the Appalachian invert, suggests a further delineation of the Coal Measure rocks. It has already been shown that when a coal horizon has a cap-rock, that horizon consists of four members and they are the only constant rocks in the coal measures. The same persistency obtains when a coal horizon has no cap-rock, but, in that case, the horizon consists of only three members. Besides these three or four regular members of each individual coal horizon, there are other rocks in the coal measures and they have caused all the confusion among geologists and prospectors. They are the conglomerates, the false-bedded sandstones, the sandy shales and plastic clay-shales or alternating fillers between horizons.

While the regular members of a coal horizon are absolutely persistent and even continuous, over vast areas, these inconstant, alternating fillers lie in narrow zones, sinuous, of course, but parallel with each other and with some shore-line. The reason is apparent, if you think for a minute, that they represent land sediment carried from some eroded land surface, into the depressed area. When land sediment is carried into the sea, it is at once assorted. The coarse and heavy materials are precipitated nearest the shore, in a sinuous zone, and they form the conglomerates. The next coarsest are carried a little further out and they form the false-bedded sand-rocks. The next coarsest are carried still further out and they form the sandy shales. Finally, the purely argillaceous matter, remaining suspended in the water longest, is carried out farthest of all and it makes the plastic clay-shales.

Every phenomenon in nature is a logical sequence. Obviously, when each coal horizon went down and its coal forests were inundated, with muddy water, that sediment would have fallen somewhat evenly over the whole floor. Whatever plants or branches, with their foliage were left standing erect, would have been caught in that first fine sediment. The fine sediment would naturally have filled up the spaces under these branches and foliage first and then have settled down on top of them. All of those beautiful impressions of barks, branches and foliage, we find in the roof-shale of a coal mine, were preserved in that way. They help to make the cleavage planes in those shales.

If the water had afterwards become clear and it were salt water, that whole area would soon have been colonized by marine life. After having been thus occupied by marine life, during an incredible period that whole area would have been covered with organic products. A large portion of these would have been dissolved or ground down into a fine mud, in which other more hardy individuals would have been buried and preserved, just as we find them. The fossils of animal life, preserved in the cap-rocks, like the stems and foliage preserved in the shales, have undergone various alterations. Yet, while they do not contain the exact materials they contained when planted in the mud, which afterwards made the major part of the rock, they have, in numerous cases, retained their most delicate features. In many of the older argillaceous limestones, purely siliceous matter has replaced the original materials of the fossils and they are now pure quartz. In some cases they are preserved in iron pyrites and in other cases the pyrites has altered to limonite.

But, in the meantime, that depressed area would have been filled up and thus brought back to land surface before another coal forest could have grown directly over the last. How was it filled up? In the manner just described—by land sediment, carried in from some eroded surface and precipitated in narrow zones, according to its lithological characters. The different zones, according to their lithological characters, would have produced just such rocks as these inconstant, false-bedded and alternating Fillers, between regular coal horizons, that have given the geologists and prospectors so much trouble.

The Lower Coal Measure, or that section embraced between the basal sandstone and the Mahoning sandstone cap-rock, represents, in all of its rocks and fossils, the products of land sediment and fresh-water life. It is, logically and emphatically, the first division of our coal measure section. In all other things, except its eight coal horizons of only three members each, it is radically unlike either the Middle or the Upper Coal Measures. It is easily distinguishable on either physical or paleontological grounds and is, therefore, placed by itself in the lower division of the section. It represents the age in which those giant coal plants flourished—the Lepidodendrids and the Cordiates. Their relics are abundant in the roof-shales along with Crustaceans and other land and fresh water species.

That it does represent an age of low mud-flats, or mud-islands, surrounded by shallow fresh-water lakes, is further demonstrated by the fact that it was the age in which most of our iron-ores were deposited. Indeed, the iron-ores of Pennsylvania, Eastern Ohio, Tennessee and Alabama, may easily be referred to the one-time black carbonates, precipitated on the floors of shallow lakes, on the same horizons on which the coal forests grew. In fact, the coal lenses, in the Lower Coal Measures, do alternate with deposits of black carbonate iron-ore, on the same horizons. If, in the folding of Earth's flexible shield of solid masses, one of those vast beds of shale and black carbonate iron-ore, deposited on the floor of a shallow lake, had been caught in an upward fold or arch and subsequently denuded of its covering, the natural process of reconstruction would logically have concentrated and converted the iron into red oxide, and thence into a hematite. The black carbonate. precipitated on the floors of the shallow lakes by the organic acids derived from the coal forests, was in the form of numerous lenses buried in immense sheets of clay-shale. The lenses consisted of about equal parts, iron, mud and coal-dust, or other organic matter. The argillaceous shale, having been first washed out, the lenses of carbonate would have been thus concentrated into beds. New conditions and reagents would have replaced the carbon with oxygen and have made an oxide of the carbonate. Further concentration and crystallization would have converted the oxide into a hematite. In this flexible shield, of our cosmic Mother Earth, on which we walk, these processes are going on continuously.

The first horizon of the Lower Coal Measure is productive, in a small way, near Lewiston and about Monticello and Maywood, in Lewis county. It is sufficiently developed, in spots, in the Kansas City and Hamilton zone, to be productive. In Eastern Johnson county, in the west bluff of Clear Fork Creek, about one-half mile below the Missouri Pacific Railroad bridge, at a place called the Rocky Ford, it is represented by an immense bed of dark clay-shale and lenses of black carbonate iron-ore. The second horizon of the Lower Coal Measure has been its most productive horizon in Missouri. The famous Montserrat coal, in Johnson county, occurs in this horizon. Millions of tons of it have been mined in that locality, and still large isolated lenses or productive basins lie untouched between Montserrat and Concordia. Also the fifth or last horizon that is at all developed in the Lower Coal Measure of that region has been productive in a small way in that locality. Above it, some distance, resting on ferruginous shales and iron concretions comes the widespread Mahoning Sandstone, cap-rock of the Lower Coal Measure.

The Mahoning Sandstone, in its full development, consists of three divisions: 1, its lower ferruginous and shaly; 2, its middle or massive; 3, its upper group of flag-like layers, growing gradually thinner upwards. The middle or massive portion has yielded much good building stone in many different states and localities. In the Appalachian invert it has reached its greatest development. About Van Buren and Fort Smith, in Arkansas, its three members are widely separated by two immense shale-beds. In Southwest Missouri, it is in many places the surface rock. It is the principal surface rock round about Clinton, in Henry county, where it yields most or all of the ordinary building stone. Going overland from Warsaw to Clinton, you pass gradually over the Lower Coal Measure; from the basal sandstone to the Mahoning Sandstone cap-rock.

The wide-spread development of this rock, is one of the most difficult problems in all of the Coal Measures. The ordinary conditions of deposit make sand-rocks, logically, local deposits. But this Mahoning Sandstone cap-rock of the Lower Coal Measure may be recognized, from the eastern slope of the Rocky Mountains, to the summit of the Alleghanies; where-ever the Lower Coal Measure rocks are exposed. Silicified Stigmaria and sections of the stems of the Lepidodendrids and Cordiates, of the Lower Coal Measure Age, are often found imbedded in its structure. It is sufficiently argillaceous, micaceous and ferruginous, to destroy its beauty, but it is, withal, a durable and useful rock.

THE MIDDLE COAL MEASURES.

Now comes the Middle Coal Measure, resting on the Mahoning Sandstone and reaching up to the mysteriously "Spotted Rock," or Bethany Falls limestone, as it is locally called in Western Missouri. In it, most of our productive coal beds occur. Our Middle Coal Measure section embraces twelve distinct and persistent horizons, all of which are well defined and doubtless productive somewhere. The first horizon, represented by the lower Windsor coal, in Henry county, the Waverly coal, in Lafayette county, and the only coal about Glasgow, in Howard county, is not very productive in Missouri. In its normal or regular development, that horizon has a hard blue argillaceous limestone cap-rock. But, as if to show that it did not reach such a development, its cap-rock is frequently missing in our first or eastern shallow zone.

The second horizon is the most productive in all of our Middle Coal Measure. It is so individualized by the absence of any cap-rock, by persistent but isolated lenses or "Batts" of Productus, Chonetes, Coal-dust and mud, or by its clay-dykes, as to make it easily recognized. The "Batts" or lenses, sandwitched in between the coal and the roof-shale, together with the absence of a cap-rock and the presence of one of the greatest and most variable alternating Fillers in the Coal Measures, suggest unusual conditions at that epoch. The fossils, meantime, lying in isolated lenses or patches, immediately on the coal, suggest a short period of clear water, during which the subsided area was colonized by these marine species. Again, the fact that they lie only in isolated patches, suggests that a sudden influx of muddy water destroyed all these colonies.

The clay-dikes, which are merely the under-clay, suggest that long after its subsidence and after a great weight of overlying mud or water had accumulated, the coal contracted laterally, in masses; leaving the voids which the plastic under-clay was forced to occupy. Along the walls of those dykes, which invariably stop at the roof, there are absolutely no indications of erosion. However, when these characteristics are absent, the alternating character of the roof is a sufficient individuality by which to recognize it. This is the productive horizon at Danforth and Novinger, in Adair county; at Bevier, Ardmore and Lingo, in Macon county; at Huntsville and Higbee, in Randolph county; at Rich Hill, in Bates county; and it is the the big seam at Windsor, in Henry county. It is also the productive coal at Leavenworth, Kansas; seven hundred feet below the bank of the Missouri river.

Now, the great, variable or alternating, Filler, that lies on this second horizon, between it and the third, is one of the rocks that have given geologists and prospectors so much trouble. A cross-section of our coal field, correctly delineated, will show this rock, in the Eastern or shallow zone, varying in thickness between five and forty feet; in the second or Grand River zone, between eighty and one hundred feet; in the third on Platte River zone, between one hundred and eighty and two hundred feet; in the fourth or Forest City zone, between two hundred and fifty and three hundred feet. A cross-section of that rock, alone, fixes the greater subsidence towards the Laramie sea, in Paleozoic time. The fact, that its alternating members lie in sinuous zones, parallel with the curving shore-line, on the east, and are so much thicker on each terrace of the bed-rocks, proceeding westwards, accounts largely for the greater depth of our coal measures in that direction. Inasmuch as that it alternates frequently between a false-bedded sand-rock, a sandy-shale and a plastic clay-shale, the drill records of prospectors and the "old river beds" of geologists, have so mystified the physical structure of our coal measures, that the unfortunate reader could not understand it.

The occurence of Keokuk or Carthage limestone, in the South bluff of the Missouri river, at Miami, and of White Rock, a portion of the Filler, now under discussion, on the same level across the river, unfolds two things of great importance, viz: That our four different coal measure zones of unlike thickness are resting on as many different terraces in the bed-rocks; and that the sand-rock Filler, known as White

Rock, could not have been a river bed at any period. The writer found the second horizon of the Middle Coal Measure under it and the third horizon, fully developed resting on it; a few miles distant to the westward. In fact, the same false-bedded, sand zone reaches from a point, back of Brunswick, in Chariton county, continuously southwestward between Waverly and Lexington, by Higginsville, across Jackson and Cass counties and far into Kansas. From the point mentioned, in Chariton county, it swings round gradually to the northwestward and reaches, along the western edge of the Chariton valley, into Iowa. It marks the dividing line or dislocation, between the first and second terraces or zones, as you choose to call them. In this rock, at the Confederate Home, and in its equivalent, at Kansas City, a black bituminous oil occurs in very considerable quantities.

In the Brush Creek shaft, near Kansas City, as already indicated, the equivalent of this rock is a false-bedded sandstone. In the Randolph Shaft, six miles north, it is a plastic clay-shale. In the Riverside Mine, at Leavenworth, Kansas the roof of the south half is false-bedded sand-rock, while the roof in the north half of the same mine is sandy and plastic clay-shale. Hence, in at least three of our Coal Measure zones, the alternating character of this great Filler has been fully demonstrated.

On top of the Alternating Filler, just described, rests the third and most interesting horizon of the Middle Coal Measure. The coal is not generally so thick as that of the second horizon, under it, but it is very generally better. It is the productive horizon at Perry, in Ralls county; at Wellsville, in Montgomery county; at Mexico, in Audrain county; at Macon City, in Macon county; at Stahl, in Adair county; at Zola, in Schuyler county; at Mendota and Unionville, in Putnam county; at Marceline and Brookfield, in Linn county; at Trenton, in Grundy county; at Tom Creek, in Caldwell county; at Brush Creek, in Jackson county; at Concordia, in Lafayette county; at Bristle Ridge, in Johnson county; and it yields the gas-coal, mined near Clinton, in Henry county.

This horizon has the regular complement of four members: the under-clay, the coal, the roof-shale and the cap-rock. The cap-rock is usually single-bedded or one massive layer of argillaceous limestone. The coal is usually in three layers with open cleavages between them. In many places, however, there are parting-clays or shales between the bedding planes of the two partings. The three members which make up this coal bed vary greatly in thickness in different localities. That variation and the presence or absence of one or both of the parting-clays are very confusing to many people. Again, in many places, there is a very considerable thickness of clay-shale or "Soapstone," deposited between the roof-shale or slate and the coal. In that case the horizon is not only more difficult to recognize, but the roof is usually bad. But, besides the general character of the coal and its geological relations or sequence, there are two characteristic features, always present, by which the horizon may be recognized: 1, the oblong, oval or flattened, concretionary bowlders, which occur in the roof-shale; 2, the small Lamellibranchs usually Cardiomorpha, the Bellerophon and Discina, which are found in those bowlders. One or all of these fossils have been found in the bowlders at every mine mentioned in connection with this horizon. It is the Lamellibranch horizon of the Middle Coal Measure.

Between the third and fourth horizons the fillers do not vary so much in either thickness or character. They are usually sandy or plastic clay-shales, with some rough concretions of lime, clay and iron pyrites towards the top. The fourth horizon of the Middle Coal Measure of Missouri is productive only at Higginsville, Mayview, Lexington and two or three other places along the Missouri River bluffs, in Lafayette county; at Richmond and Camden, in Ray county; and at Missouri City, in Clay county. The coal is easily recognized, even on the railroad cars, by its coarse slab-like structure, its slaty looking bedding planes and its intensely white gypsum scales on its joint faces.

The fourth horizon is further individualized by its more crystalline and many-bedded cap-rock. It is more a crinoid and coral product than any other Coal Measure rock above or below it. It is, in fact, where it has been much weathered, a mass of very nearly pure carbonate of lime. Its freedom from argillaceous matter and magnesia has suggested its use in the manufacture of Portland cement. When found deep in the ground, however, its structure and other lithological characters are very different from what they are in a weathered outcrop. Where this rock is most crystalline, the abundance of crinoid relics in it, has given it the name, crinoidal or encrinital limestone. In other localities, where it is more argillaceous, it contains very many Productus, Chonetes and Bryozoa.

Seeing, now, that this delineation is about to become too elaborate for this occasion, we will hurry through the sixth, seventh, eighth, ninth and tenth horizons, all of which have their full complement of members, but none of which is productive except the last, at the Estes Mine, near the Woodland Mills, on Locust Creek, in Linn county. On the cap-rock of the tenth horizon rests another one of those great alternating Fillers. All up and down the Locust Creek and Grand River valleys, this great Filler is exposed in many places. That it is an alternating Filler, is shown by the fact that at the Diamond Brick Works, near Kansas City, it is the plastic clay-shale there used for màking vitrified paving brick. At the Brush Creek Mine, two miles north, it is partly shale and partly false-bedded sand-rock. At the Randolph Shaft, six miles further north, it is entirely a false-bedded sand-rock. At Woodland Mills, in Linn county, it is partly shale and partly false-bedded sand-rock. In a wide zone across the northeastern part of Carroll county, and about parallel with the line of the Burlington Railroad track, it is the surface rock. At Trenton, on the east side of Grand River, it is sandy shale; on the west side, above the Water Works, it is a false-bedded sand-rock. About Princeton, on both sides of Grand River, it is seen alternating from plastic clay-shale to false-bedded sand-rock.

On top of the second great alternating Filler of the Middle Coal Measure, comes the eleventh coal horizon, with the Hydraulic limestone for its cap-rock. Next, and last, the Bethany Falls limestone. These rocks are both quarried for building stone at Milan, in Sullivan county; the Hydraulic on the southwest and the Bethany Falls on the southeast. They both occur in the west bluff of Grand River, above the Trenton water works. Again at Princeton, where the latter is quarried extensively for the Rock Island Railroad Co. Both of these horizons, the eleventh and twelfth, are exposed in many places in the Blue Valley, about Kansas City. The four members, under-clay, coal, roof-shale and cap-rock of each, are nearly always present; but nowhere productive to any considerable extent. In the north bluff of the Missouri River, between Randolph and Missouri City, the Bethany Falls limestone, projecting out just above the level of the Wabash Railroad track, is very conspicuous. In time of low water, there is another good exposure, in the south bank of the Missouri River, under the Kansas City Railroad bridge. Again, in Washington Park and about Leeds, the big weathered blocks that have been detached and have slipped down the talus slopes are good illustrations of that rock. Draw a line, from Harrisonville to Kingsville, thence to Mayview, thence to Richmond, thence to Milan and thence north to the Iowa line, and you have nearly its eastern limit.

Two miles from Kingston, at the Klondike Quarry, and again at Princeton, the Bethany Falls limestone has a pronounced oolitic texture. Oolitic, of course, refers to the analogy between the texture of the rock and a mass of fish-eggs. It means a reconstruction of the rock minerals, by which a greater or less proportion of them have taken the form of little geodes. That it adds nothing to the value of the rock is shown by the fact that neither the oolitic Niagara at Louisiana, nor the oolitic St. Louis limestone at Ste. Genevieve, are preferred for building stone. However, in so recent a rock as the Bethany Falls limestone, oolitic texture or structure does suggest the presence of Bauxite. In France, some such rocks yield that valuable mineral in considerable quantities. Bauxite is the mineral or ore whence Aluminum is most easily extracted for commercial use. Prof. Swallow took the pictuesque falls in Big Creek at Bethany, Harrison county, for the typical exposure of that rock, and hence its name.

THE UPPER COAL MEASURES.

The Upper Coal Measure follows after and rests on the Bethany Falls limestone. On the last-named rock lies a variable filler of clay-shale usually and then the first horizon of the Upper Coal Measure. Although its full complement of members are generally present, the coal is rarely ever thick enough to have an economic value. The cap-rock, a many-bedded, cherty limestone, is the most interesting member of that horizon. In it have been found some very fine specimens of Nautilus, Productus punctatus and Bellerophon. That rock has been named the Parkville limestone, because it is there exposed in its full development and is easy of access. From the Perkins' quarry, four miles east and opposite Kansas City, where it has been worked extensively, it may be traced continuously to Parkville and beyond to the westward. A large mass of it is protruding through the soil, behind the Parkville Railroad station.

On the Parkville limestone, lies another variable filler, usually clay-shale, and then the second horizon with a massive false-bedded limestone for its cap-rock. This rock is conspicuously exposed in the corner of the bluff at Kansas City, turning from Sixth street towards the Union Station. There is, however, another rock above it that has contributed more material to the building of that city and *it* is better named the Kansas City limestone. We will reach it presently. Inasmuch, as that none of the nine typical coal horizons of the Upper Coal Measure are yielding any considerable quantity of coal, in Missouri, except the ninth and last or Quitman horizon, it is not worth while to dwell on any of the others, further than to name them in their natural order of occurrence and one or two typical exposures.

After the Massive False-Bedded Limestone, comes another filler and then the third horizon, with the Weston limestone for its cap-rock. North and south of Weston, about level with the Burlington Railroad track, lies a massive argillaceous limestone abounding in the interesting little fossil, Fusulina cylindrica. It reminds us of the fact, that everything in nature has an important function to perform, and that the most insignificant organisms have been the greatest rock-builders.

Resting on the Weston limestone is another filler and then the fourth horizon with a thin, single-bedded, argillaceous limestone cap-rock. After that, comes another great variable filler, in which the Waldron sandstone alternates with shale, in other places, and then the fifth horizon, with the Kansas City limestone for its cap-rock.

The Kansas City limestone, cap-rock of the fifth horizon of the Upper Coal Measure, may be a familiar land-mark to many people, because it is the rock on which rests the Keely Cure Institution, in full view from the Kansas City Union Station. It is also a conspicious object in that part of the city which lies between the Midland and Victoria Hotels. That rock, like the St. Louis limestone to that city, has contributed more rough but good building material to the building of Kansas City than any other. Under it lies the coal lens that has been sometime worked near Hall's Station.

Next, after the Kansas City limestone, in our Upper Coal Measure section, comes another clay-shale Filler and then the sixth horizon, with a hard, thin-bedded, compact and blue limestone for its cap-rock. That rock is exposed in many places about St. Joseph. In fact, it is exposed all along the bluffs, between Weston and Bean Lake, just above the Kansas City limestone; which latter takes on the appearance of Bethany Falls limestone, from there to Amazonia.

Between the sixth and seventh horizons is another Filler and on top of the seventh rests the St Joe limestone for its cap-rock. The St. Joe, much the same as the Kansas City limestone, is a rough and many-bedded rock; but it, too, has contributed more material to the building of St. Joseph than any other native rock.

Now comes an interesting geological deduction. Immediately over the St. Joe limestone and almost in contact with it, in the St. Joseph quarries, is the Nodaway limestone, cap-rock of the eighth horizon of the Upper Coal Measure. Between these two rocks, there is a thin layer of clay-shale, varying in thickness between one and three inches. At Corby's Hill, about five miles south and east across the Platte River, that shale-bed is apparently not less than one-hundred feet thick. The Nodaway limestone lies in the top of Corby's Hill, or very nearly the top, while the shale-bed under it extends downwards and out of sight, below the low water-level in Platte River.

Moreover, there is, near by, an exposure of the fire clay, coal and roof-shale, of the eighth horizon, between the Nodaway limestone and the great shale-bed under it. Clearly, the St. Joe limestone must lie in the form of a trough or invert, coincident with the Platte Valley. In the axis of the upward fold or arch, the St. Joseph stone quarries are situated and there the Nodaway, rests on the St. Joe limestone; with only two or three inches of shale between them. The Nodaway limestone, the only hard rock exposed in Corby's Hill, is there apparently no higher above sea-level than it is in the St. Joseph quarries.

It follows logically that a cross-section of the Platte Valley, starting from the Black Snake quarries and passing through Corby's Hill, delineated in a vertical zone, would show the St. Joe limestone lying far below the bed of the Platte River and describing the east half of an arch, between that point and the Missouri River. The shale-bed, between the St. Joe and Nodaway limestones, would lie, like a wedge, with its thick end at Corby's Hill and its thin end at the Black Snake quarries, just as it occurs. Furthermore, it follows that the track of the Missouri River has cut into that arch, between Nodaway Station and Amazonia, and removed the superficial west half, from Amazonia southwards; while St. Joseph sits on the remaining east half.

Now, if the Trenton limestone does exist, under St. Joseph, and does lie in the form of an invert under the Platte Valley, and in the form of an arch under the superficial arch, between the Platte and the Nodaway, this conclusion follows: One or more of the twenty-eight coal horizons therein contained ought to be productive; one or more of the false-bedded fillers, between the coal horizons, ought to contain large quantities of black, bituminous oil or asphaltum; one or more of the under-clays ought to yield good fireclay; lower down, towards the Trenton limestone, there ought to be sand lenses filled with petroleum. On the other hand, in the axis of the arch described, there ought to be plenty of natural gas. One hole in the center of the invert and one in the axis of the arch ought not to be considered too much for such logical possibilities.

Now, proceeding with the delineation of our Upper Coal Measure section, the Nodaway limestone or cap-rock of the eighth horizon, is the most interesting member of that section. Its Fusulina beds and Bryozoan horizon are everywhere pronounced and it has yielded many fine specimens of Orthoceras, Pinna peracuta, Allorisma, sub-cuneata and Myalina subquadrata. Indeed, it is the Lamellibranch horizon of the Upper Coal Measure. It is named the Nodaway limestone, because it has been so extensively quarried alongside the Burlington Railroad track, just west of the Nodaway River, in Holt county. Furthermore, it is exposed in many places in Nodaway county at the base of the Quitman coal horizon.

Resting on the Nodaway limestone and capped by a massive argillaceous limestone is the Quitman, ninth or last, horizon of the Upper Coal Measure, and the twenty-ninth or last horizon of the Paleozoic Coal Measures. This horizon is productive near Arkoe, in the valley of the Hundred and Two, and at several places in the valley of the Nodaway. At the Carpenter Mine, near Quitman, where it reaches a thickness of two and one-half feet, it has yielded and is now yielding a considerable quantity of fairly good coal for local use. So much for the Coal Measures.

THE PERMIAN.

It must be apparent to the reader, that the division of the Middle and Upper Coal Measures, on the Bethany Falls limestone horizon, is more for convenience than for any other reason, and is, therefore, essentially an arbitrary division. Now, the division of the Paleozoic Coal Measures and the Permian, on the cap-rock of the Quitman horizon is also, to some extent, an arbitrary division. In either case, we have no such substantial reason as we had for the division of the Lower and Middle Coal Measures, on the Mahoning Sandstone. In that case, we had, in all except the coal itself, a radical change from land and fresh water life, to marine life and their essentially different physical conditions. But the Bethany Falls limestone and the Quitman cap-rock are sufficiently individualized and far enough apart to make convenient divisional planes. The Bethany Falls is the surface rock over large areas in the second or Grand River zone, the Quitman cap-rock is the surface rock over a large portion of the fourth or Forest City zone.

There is this reason, however, for placing the three or four hundred feet of our geological record in Northwest Missouri, above the Quitman cap-rock, in the Permian; there is neither coal nor under-clay, in any horizon above the Quitman cap-rock; but there is both coal and under-clay in every coal horizon described below it. Furthermore, the Permian, at most, is little more than the closing out of the Paleozoic Coal Period. These remarks, the reader will, of course, understand, do not apply to any other part of Missouri. Every geologist knows that the coal fields of the western half of this Continent are not in the Paleozoic Coal measures. On the other hand, when we shall have reached the Tertiary deposits, in Southeastern Missouri, we will have Lignite beds and other economic deposits of a radically different character. Having three or four hundred feet of rocks and shales, on top of the Quitman coal horizon, in Holt county, without either coal or under-clay in them, and Tertiary deposits in Southeastern Missouri, to describe hereafter, is sufficient reason for placing the Forest City group in the Permian.

The main reason, however, for putting the Forest City group in the Permian, is, to eliminate it from our productive Coal Measure section, and thereby simplify the subject. Like the question referred to in discussing the individualities of the Burlington and Carthage limestones, it is a bone of contention which carries no meat with it. While the State Geologist is open to conviction, on both questions, he simply wants to settle all such questions and eliminate them before publishing either one of his finished reports. Such stuff is tiresome to the average man, who gets his living by the sweat of his own brow. For such men, mainly, will the Reports of this administration of the Survey be designed.

Now, to get quickly at a right conception of our Permian deposits, let us think of the whole mass, as the one-third part of a lens, with its thickest corner or obtuse angle, located near Forest City, and its thin, ragged edge terminating somewhere round about Rock Port, Tarkio, Elmo, Maryville, Bolckow and Amazonia. It evidently fills a portion of the deepest abyss, in the eastern margin of our Laramie sea. Its basal member reaches out the farthest; perhaps, beyond Tarkio, Elmo and Maryville. Its next member not so far, and so on, until its last or upper member, a thick shale-bed, on the hill back of Forest City, covers relatively a very small area. It is a monotonous mass of mud-rocks or argillaceous limestones, with alternating fillers between.

Starting from the argillaceous cap-rock of the Quitman Coal horizon, which we have taken for the top of the Paleozoic Coal Measures, the first member of our Permian section is a thick shale-bed, then a single-bedded shaly limestone; next a thick shale-bed, then a ferruginous and massive limestone; next forty feet of shale and thin layers of dirty limestone, then thirty feet of blue shale; next the Forbes limestone, then ten feet of blue plastic shale; next a thin-bedded, highly fossiliferous limestone, then another bed of shale; next the Curzon's limestone, then the Forest City sand-rock, alternating with clay-shale; next the Forest City limestone, then calcareous shales; next a thin-bedded and ferruginous limestone, then another clay-shale; next a thin-bedded limestone or mud-rock, and finally one hundred feet of clay-shale. In its thickest place, this monotonous mass is not less than three hundred feet thick and it might all be well named, a filler.

Now, starting from the top of the last mentioned shale-bed at Forest City, which is the highest horizon of our Permian, and estimating the thickness of our Coal Measures at that point to be fifteen hundred feet, the total depth from the surface to the Subcarboniferous bed-rocks, should be approximately eighteen hundred feet, or a little more than one-third of a mile. If that estimate is about correct, the whole thickness of our geological record, at that point, should be not less than two-thirds of a mile. Then we have to add whatever Cretaceous and Tertiary we have, in Southeastern Missouri. Then the glacial drift of North Missouri and, finally, the River Loess; which will bring the whole section of our geological record up to about one vertical mile.

The Geologist proposes to sketch a complete section of our geological record, individualizing each member by some particular color or character, and place that sketch in his Report on the Structural Geology of Missouri. The color or character, by which each member of our geological record is individualized, in that section, will be used to represent that member in all cross-sections and maps, issued by him thereafter. He proposes, furthermore, to publish with that sketch, the characteristic fossils of each geological horizon.

THE GLACIAL PERIOD.

Along the line of the Keokuk and Western Railroad, about Lancaster and Memphis, the glacial drift reaches the surprising depth of two hundred and fifty or three hundred feet. It lies over North Missouri, much like five or six flint arrow-heads, large and small, laid down on our small map, some little distance apart, with their wide ends across the Iowa line and their points towards the Missouri River. It consists mainly of fine plastic clay, sand and gravel, with rounded and angular fragments and occasional massive blocks of crystalline and igneous rocks; brought from the far North, in the glacial period or ice age, as you choose to call it.

Having said, so often, that everything we see in nature, is a logical sequence, the writer will now offer, what seems to him, the only logical chain of physical conditions, which could have produced and terminated that awful period. Assuming, for the sake of brevity, that the first emerged portion of our continent was the floor of a Primordial sargasso sea, the equatorial current of the ocean must have swept around it and through the Artic sea. That would have carried equatorial heat far into the Polar region. But the logical sequence of Earth's function is continuous contraction and readjustment of her flexible shield to a smaller center. Contraction means the letting down of her greater inverts first; and that means more land emergence. If, long after the Coal Period and in comparatively modern time, the emergence of land, around the Artic sea, had stopped the equatorial current from traversing that region, the physical conditions would have been sufficiently altered, to have produced the requisite cold.

If then, a vast accumulation of ice had occurred, before sufficient outlets had been cut through the land barriers, a time would have come when the accumulation was so great, that the axial motion of the Earth would have thrown it towards the Equator. Sufficient outlets, cut by that process and by subsequent erosion, would have established and maintained the more equable conditions we now enjoy.

THE TERTIARY AND QUATERNARY.

Having, as yet, no definite knowledge of any Cretaceous deposits in Missouri and very little knowledge of the volume of Tertiary deposits, in Southeastern Missouri. those sections, together with the Quarternary will be left for future discussion. Without any assistance in the office, other than the very efficient lady Secretary, Miss E. L. Carter, the energies of the Geologist have been somewhat heavily taxed; to keep up with his correspondence and, in the meantime, do effective field work. He has, however, gotten over about half of the ten cross-sections already mentioned. He will have gotten over all of them by the fall of 1899.

ACKNOWLEDGMENTS.

Here and now, your Geologist, finds much pleasure in acknowledging the valuable assistance rendered by Mr. C. F. Marbut, Professor in charge of the Geological Department of the State University. Professor Marbut, a very courteous gentleman, and accomplished scholar, has contributed much to the success of this Survey. He, having been connected with the Survey for several years, was given the entire work of preparing volume XII of the Reports, for the printer. Volume XII, on miscellaneous subjects, by Professors Broadhead, Shepard and Marbut, illustrated with the topographic maps and other engravings, contracted for by Doctor Keyes, is in the hands of the publisher, and will soon be ready for distribution.

Besides Professor Marbut and Professor Jones, who has been already mentioned, your Geologist is greatly indebted to Professor R. R. Rowley, Principal of the High School at Louisiana, Mo. Professor Rowley has been a persistent student of Paleontology for twenty years and has thus earned for himself a position in the first rank of American Paleontologists. During the months of June, July and August, 1898, the State Geologist, accompanied by Professor C. F. Marbut, with Mineralogy for his specialty, Professor R. R. Rowley with Paleontology for his specialty, and Leo Gallaher, a student of the State University, with Biology for his specialty, traversed four of the cross-sections and explored a large part of Missouri. These last named gentlemen returned to their respective employments, the first of September, and the State Geologist was assisted, thereafter in field work, by F. Thomas Ransom of St. Joseph.

Mr. Ransom, a courteous young gentleman and an expert at cleaning and mounting geological specimens, has been retained in the office. The Geological Record of Missouri is now fairly well illustrated, in the State Collection of specimens. Each geological horizon, in its natural order of occurrence, is emphasized and individualized, by specimens of the rock, its economic deposits and characteristic fossils. The room is not exactly adapted to the purpose, but it is, by far, the best lighted and affords better facilities for displaying the State Collection of specimens than any other room in any of the State buildings.

Having continued on field work until the middle of November, your Geologist's time has been quite fully occupied with work that had accumulated in the office. Hence, he has had not exceeding one week in which to prepare this Biennial Report for the printer. But when you have taken into account the fact that it was written thus hurriedly, you will doubtless excuse its imperfections. Believing, as he does, that when a man knows something, right well, he can always explain it, and that exhaustive field work is the only way by which any man can qualify himself for delineating the geology of Missouri, your Geologist prefers to say very little now, and that little to the point.

Knowing, as he does, that the economic function of this Survey, is what the people most appreciate who pay for it, the only ambition of your Geologist is, to unfold the truth, in its beaming simplicity, and in as little space as possible. The forthcoming Reports, on the Structural Geology and Economic Deposits of Missouri, will, therefore, be comprehensive, concise and to the point, whether they are otherwise interesting or not.

Very truly yours,

JNO. A. GALLAHER,
State Geologist.

EXPENDITURES.

Date.	Vo. No.	To whom issued.	Amount item.	Amount voucher	Totals.
1897 April....	1780	Chas. R. Keyes—			
		salary 3 months	$750 00		
		railroad fare	3 75		
		office expenses	19 26		
				$773 01	
	1781	E. L. Carter— salary 3 months	....	150 00	
	1782	C. B. Lane— salary 3 months	....	60 00	
	1823	Pacific Express Co.—			
		for January	3 40		
		"	4 85		
		for February	1 80		
		for March	5 41		
				15 46	
	3150	St. Louis Paper Co	....	4 25	
					$1,002 72
May.....	3475	Chas. R. Keyes—			
		salary for April	250 00		
		traveling expenses	44 20		
		office expenses	2 45		
				296 65	
	3476	E. L. Carter— salary for April	....	50 00	
	3477	C. B. Lane— salary for April	....	20 00	
	3478	Pacific Express Co	1 65		
		" "	3 40		
				5 05	
	3663	Tribune Printing Co.—			
		work on Vol. X	97 16		
		work on Vol. XI	420 00		
				517 16	
	3720	G. W B. Garret— personal expenses	....	16 95	
	3721	John S. Logan— personal expenses	....	19 30	
					925 11
June	3891	Pacific Express Co	....	15 15	
	3912	E. M. Shepard— personal expenses	....	35 70	
	3913	O A. Crandall— personal expenses	....	21 40	
	3525	Chas. R. Keyes—			
		salary for May	250 00		
		traveling expenses	35 65		
				285 65	
	3926	E. L Carter— salary for May	....	50 00	
	3927	C. B. Lane— salary for May	....	20 00	
	3928	C. F. Marbut—			
		services for 3 days	12 00		
		expenses Jefferson City	10 55		
				22 55	
					450 45
July.....	4419	Chas. R. Keyes—			
		salary for June	250 00		
		expenses for June	36 00		
				286 00	
	4420	E. L. Carter— salary for June	....	50 00	
	4421	C. B. Lane— salary for June	....	20 00	

EXPENDITURES—Continued.

Date.	Vo. No.	To whom paid.	Amount item.	Amount voucher	Totals.
July.....	4422	Missouri Pacific R. R. Co	....	$3 36	
	4442	Pacific Express Co	....	7 21	
	4508	T. B. Marbut—			
		salary to July 1	$31 65		
		traveling expenses	20 05		
		expenses Jefferson City	9 85		
				61 55	
	4509	C. F. Marbut—			
		salary 6 days	20 00		
		traveling expenses	28 00		
				48 00	
	4599	Tribune Printing Co.—			
		work on Vol. X	44 24		
		work on Vol. XI	142 24		
		press-work	201 15		
				387 63	
	4632	A. J. Shockley—			
		office supplies	....	2 50	
	4836	E. M. Shepard..			
		personal expenses	....	24 75	
	4740	Chas. R. Keyes—			
		salary to July 15	125 00		
		expenses to July 15	6 75		
				131 75	
	4741	Chas. B. Lane—			
		salary to July 15	10 00		
		overtime and expenses	12 50		
				22 50	
	4742	John Moore—			
		help in moving	....	3 00	
	4743	O. A. Crandall—			
		personal expenses	....	7 80	
	4744	C. W. B. Garret—			
		personal expenses	....	23 20	
	4745	John S. Logan—			
		personal expenses	....	21 30	
	4753	St. Louis Paper Co	....	1,596 00	
	4757	T. B. Marbut—			
		salary to July 15	50 00		
		traveling expenses	35 80		
				85 80	
	4762	E. L. Carter—			
		salary to July 15	....	25 00	
	4776	Tribune Printing Co.—			
		work on Vol. X	....	115 64	
	4841	Tribune Printing Co.—			
		work on Vol. X	....	120 96	
	4854	Post office (box)	....	1 00	
	4867	Geo. J. Vaughn—			
		postal cards	....	5 00	
August..	5078	Pacific Express Co	....	3 70	
	5085	Jefferson Heating Co	....	165 00	
	5089	E. L. Carter—			
		salary to August 1	....	25 00	
	5090	C. B. Lane—			
		salary to August 1	....	10 00	
	5091	Fred Sessinghaus—			
		labor	....	21 25	
	5092	John A. Gallaher—			
		salary to August 1	....	125 00	
	5102	Ed. R Hogg—			
		lumber	....	29 88	
	5159	C. F. Marbut—			
		salary to August 1	100 00		
		traveling expenses	41 30		
				141 30	
	5228	Tribune Printing Co.—			
		printing	....	16 23	
	5423	Mo. Pacific R. R. Co	....	2 50	

EXPENDITURES—Continued.

Date.	Vo. No.	To whom issued.	Amount item.	Amount voucher	Totals.
August..	5464	Smith-Premier T. W, Co—			
		typewriter	$77 50		
		cabinet	45 00		
				$122 50	
	5501	Day Rubber Co		5 45	
					$667 81
Sept.....	5768	Pacific Express Co		3 25	
	5785	H. A. Swift Ice Co— ice for August		4 40	
	5794	Fred Sessinghaus— labor		62 50	
	5796	E. L. Carter— salary for August		50 00	
	5797	C. B. Lane— salary for August		20 00	
	5809	Capitol City Planing Mills		150 75	
	5804	A. J. Shockley— office supplies		13 43	
	5807	Schultz Dry Goods & Carpet Co		1 00	
	5811	John A. Gallaher— salary for August		250 00	
	5862	C F Marbut—			
		salary 20 days	66 00		
		traveling expenses	45 55		
				111 55	
	5879	Krueger & Linde— office supplies		97 41	
	5941	G. W. B. Garret— personal expenses		20 70	
	5942	John S. Logan— personal expenses		20 05	
	5943	O. A. Crandall— personal expenses		14 35	
	5987	Jefferson Heating Co — radiator		37 50	
	5995	Fleming Furniture Co— office furniture		247 01	
	6001	John N. Ross— making cases		132 03	
	6012	Ed R. Hogg— lumber		40 15	
	6110	Postage stamps		5 00	
					1,281 08
October.	6379	Pacific Express Co		13 15	
	6394	E. L. Carter— salary for September		50 00	
	6395	C. B. Lane— salary for September		20 00	
	6397	J. A. Gallaher— salary for September		250 00	
	6453	Jeff. City Light, Heat and Power Co.— office fixtures		9 30	
	6470	Sams & Wadell— office fixtures		4 00	
	6554	Ed. Holtschneider— lumber		36 04	
	6587	C. F. Marbut—			
		salary for 8 days	26 66		
		traveling expenses	5 55		
				32 21	
	6613	D. Gundelfinger— hardware		2 55	
					417 35
Nov.....	7022	Pacific Express Co		2 05	
	7037	C. B. Lane— salary for October		20 00	

EXPENDITURES—Continued.

Date.	Vo. No.	To whom issued.	Amount item.	Amount voucher	Totals.
Nov.....	7051	E. L. Carter— salary for October	....	$50 00	
	7088	Mo. Pac R'y Co	....	1 00	
	7090	John A. Gallaher— salary for October	$250 00		
		traveling expenses	20 65	270 65	
	7092	Photo Engraving Co.— plates	....	18 48	
	7091	Postage stamps	....	5 00	
	7155	Graham Paper Co.— paper	....	11 00	$378 18
Dec......	7623	E. L. Carter— salary for November	....	50 00	
	7624	Alexander Slater— salary for November	....	20 00	
	7681	F. A. Jones— assays	....	12 00	
	7695	Pacific Express Co	....	5 00	
	7707	John A. Gallaher— salary for November	250 00		
		traveling expenses	59 00	309 00	
	7717	Mo. Pacific Ry. Co	....	25	
	7723	H. A. Swift Ice Co.— ice for November	....	3 65	
	7815	Postage stamps	....	1 00	400 90
1898. Jan.	188	E. L. Carter— salary for December, 1897	....	50 00	
	189	Alexander Slater— salary for December, 1897	....	20 00	
	205	John A Gallaher— salary for December, 1897	250 00		
		traveling expenses	30 00	280 00	
	231	Pacific Express Co	....	13 90	
	252	Dan Gundelfinger— hardware	....	70	
	287	G. A. Fischer— office supplies	....	2 65	
	553	John N. Ross— glass	....	3 50	
	576	C. F. Marbut— salary for 12 days	40 00		
		expenses	2 57	42 57	
	622	Postage stamps	....	5 00	
	625	Capital City Planing Mills	....	90	419 22
Feb......	863	E. L. Carter— salary for January	....	50 00	
	864	Alexander Slater— salary for January	....	20 00	
	899	Pacific Express Co	....	3 50	
	906	John A. Gallaher— salary for January	250 00		
		postoffice box rent	1 00	251 00	
	1060	G. W. B. Garret— personal expenses	....	20 70	
	1061	O. A. Crandall— persanal expenses	....	13 60	
	1114	G. C. Broadhead— services on Vol. XII	....	113 50	
	1181	E. M. Shepard— services on Vol. XII	....	200 00	672 30

EXPENDITURES—Continued.

Date.	Vo. No.	To whom issued.	Amount item.	Amount voucher	Totals.
March ..	1454	E. L. Carter—			
		salary for February	....	$50 00	
	1455	Alexander Slater—			
		salary for February	....	20 00	
	1507	F. A. Jones—			
		assays	....	26 00	
	1508	John A. Gallaher—			
		salary for February	$250 00		
		traveling expenses	32 50		
				282 50	
	1519	Pacific Express Co	....	6 70	
	1597	Fleming Furniture Co.—			
		office furniture	....	2 00	
	1628	Geo D Barnard & Co.—			
		office supplies	....	59 33	
					$446 53
April....	2013	John A Gallaher—			
		salary for March	250 00		
		traveling expenses	15 00		
		postage stamps	1 00		
				266 00	
	2014	E. L. Carter—			
		salary for March	....	50 00	
	2015	Alexander Slater—			
		salary for March	....	20 00	
	2036	Pacific Express Co	....	3 20	
	2045	F. A. Jones—			
		assays	....	32 00	
	2046	F. Schleer—			
		trays	....	40 85	
	2062	H. A. Swift Ice Co—			
		ice	....	1 10	
	2226	C. F. Marbut—			
		services on Vol. XII	26 65		
		expenses	3 90		
				30 55	
	2307	Postage stamps	....	5 00	
					448 70
May.....	2533	John A. Gallaher—			
		salary for April	250 00		
		traveling expenses	38 50		
				288 50	
	2534	E. L. Carter—			
		salary for April	....	50 00	
	2535	Alexander Slater—			
		salary for April	....	20 00	
	2798	R. L. Polk & Co	....	6 00	
	2820	Chicago & Alton R'y Co	....	4 05	
	2865	Postage stamps	....	5 00	
					373 55
June....	3026	John A. Gallaher—			
		salary for May	250 00		
		traveling expenses	40 75		
				290 75	
	3027	E. L. Carter—			
		salary for May	....	50 00	
	3028	Alexander Slater—			
		salary for May	....	20 00	
	3029	R. R Rowley—			
		services, 8 days	26 65		
		railroad fare	6 25		
		board, Jefferson City	8 00		
				40 90	
	3098	J. Mantz & Co.—			
		engraving (Vol. XII)	....	147 12	
	3117	Pacific Express Co	....	6 00	
	3162	F. A. Jones—			
		assays	....	12 00	
	3235	G. W. B. Garret—			
		personal expenses	....	20 70	

EXPENDITURES—Continued.

Date.	Vo. No.	To whom issued.	Amount item.	Amount voucher	Totals.
June	3236	John S. Logan—			
		personal expenses..................	....	$37 35	
	3259	Mo. Pac R'y Co..................	....	1 40	
	3275	John A. Gallaher—			
		expenses special field work..........	....	13 85	
	3276	A. Hoen & Co.—			
		engraving (Vol. XII)............	....	2,244 13	$2,884 20
July.....	3602	John A. Gallaher—			
		salary for June..................	$250 00		
		traveling expenses..................	81 05	331 05	
	3603	Alexander Slater—			
		salary for June..................	....	20 00	
	3604	E. L. Carter—			
		salary for June..................	....	50 00	
	3605	R. R. Rowley—			
		salary for June..................	100 00		
		traveling expenses..................	27 60		
		board Jefferson City..................	13 50	141 10	
	3606	C. F. Marbut—			
		salary for June..................	100 00		
		traveling expenses..................	37 65		
		board Jefferson City..................	9 50	147 15	
	3607	Leo Gallaher—			
		salary 15 days..................	25 00		
		traveling expenses..................	2 90	27 90	
	3643	F. Schleer—			
		trays..................	....	26 00	
	3724	H. A. Swift Ice Co.—			
		ice for June..................	....	2 15	745 35
Aug	4032	John A. Gallaher—			
		salary for July..................	250 00		
		traveling expenses..................	105 75	355 75	
	4033	E. L. Carter—			
		salary for July..................	....	50 00	
	4034	Alexander Slater—			
		salary for July..................	....	20 00	
	4044	C. F. Marbut—			
		salary for July..................	90 00		
		traveling expenses..................	67 15	157 15	
	4045	R. R. Rowley—			
		salary for July..................	100 00		
		traveling expenses..................	53 75	153 75	
	4046	Leo Gallaher—			
		salary for July..................	50 00		
		traveling expenses..................	18 00	68 00	
	4051	Pacific Express Co..................	....	10 21	814 86
Sept.....	4650	John A. Gallaher—			
		salary for August..................	250 00		
		traveling expenses..................	171 87	421 87	
	4651	E. L. Carter—			
		salary for August..................	....	50 00	
	4652	Alexander Slater—			
		salary for August..................	....	20 00	
	4653	Pacific Express Co..................	....	50	
	4685	H. A. Swift Ice Co.—			
		ice for August..................	....	2 65	

EXPENDITURES—Continued.

Date.	Vo. No.	To whom issued.	Amount item.	Amount voucher	Totals.
	4709	C. F. Marbut—			
		salary for August	$100 00		
		traveling expenses	112 40		
				$212 40	
	4710	Leo Gallaher—			
		salary for August	50 00		
		traveling expenses	53 09		
				103 09	
	4711	R. R. Rowley—			
		salary for August	98 40		
		traveling expenses	55 95		
				154 35	
	4732	G. W. B. Garrett—			
		personal expenses	....	20 70	
	4733	John S. Logan—			
		personal expenses	....	19 50	
	4775	Postage stamps	....	1 00	
					$1,006 06
October.	5157	E. L. Carter—			
		salary for September	....	50 00	
	5108	Alexander Slater—			
		salary for September	....	20 00	
	5109	John A. Gallaher—			
		salary for September	250 00		
		traveling expenses	75 96		
				325 96	
	5160	F. A. Jones—			
		assays	....	8 00	
	5161	F. Thomas Ransom—			
		salary, 20 days	33 33		
		traveling expenses	8 42		
				41 75	
					445 71
Nov.....	5625	John A. Gallaher—			
		salary for October	250 00		
		traveling expenses	95 75		
				345 75	
	5626	E. L. Carter—			
		salary for October	....	50 00	
	5627	F. Thomas Ransom—			
		salary for October	50 00		
		traveling expenses	60 85		
				110 85	
	5628	Alexander Slater—			
		salary for October	....	20 00	
	5660	Pacific Express Co	....	1 00	
	5770	H. A. Swift & Co—			
		ice for October	....	2 47	
					530 07
Dec......	6095	John A. Gallaher—			
		salary for November	250 00		
		freight	10 65		
		postage stamps	4 00		
		traveling expenses	20 48		
				285 13	
	6096	E. L. Carter—			
		salary for November	....	50 00	
	6097	F. Thomas Ransom—			
		salary	50 00		
		traveling expenses	11 50		
		office supplies	2 00		
				63 50	
	6098	Alexander Slater—			
		salary for November	....	20 00	
	6142	Pacific Express Co	....	2 75	
	6193	F. A. Jones—			
		assays	....	8 00	
	6343	John S. Logan—			
		personal expenses	....	21 15	

EXPENDITURES—Continued.

Date.	Vo. No.	To whom issued.	Amount item.	Amount voucher	Totals.
	6344	O. A. Crandall—personal expenses	....	$14 10	
	6349	G. W. B. Garret—personal expenses	....	21 70	
					$486 33
		Total expenditures to December 15, '98.	....	....	17,846 43
		Balance December 15, '98	....	....	2,153 57
		Appropriation	....	....	20,000 00